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How Do You Know?

A Handbook of Evidence and Inference

By

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PREFACE

This book has been written primarily for wayfaring men and women who were compelled by economic circumstances to leave school at the age of fourteen or sixteen and join the throng of workers. It is an expression of fellowship for those to whom opportunities for study in youth have been theoretically offered but practically denied.

Dr. Richard Cabot, writing of the training given by the medical school, says: "He (the medical student) learns all that he is capable of learning about the huge difficult habit of objectivity; I mean the habit of facing, recording and acting upon the truth as he finds it, without those large admixtures of selfish prejudice and slovenly emotionalism which characterize the free and untrammeled American."

But it is precisely this "huge difficult habit of objectivity" which is needed by every person who purposes to justify his stay in the world; and it is hoped that HOW DO YOU KNOW? may aid in securing this habit. Whatever else the workers lose let them not yield their right to that which chiefly makes the richly intelligent life: power to acquire a share in knowledge which is of the most worth, and resolution to seek their own adventures in thinking.

With a wide field to cover, this small text-book is necessarily sketchy and broken. It has not tried to be entertaining reading, nor is it even smooth-run-

ning by means of a profusion of terms that might oil the bearings of ideas. But it has called to its pages the words of some who have traveled far in the world of research and thought; and it has emphasized as strongly as it could the declaration of Diogenes Laertius: "There is only one evil: ignorance; only one good: knowledge."

Chapters I and II may prove difficult, but they are fundamental to all that follow; consequently, their careful study is important. With a familiarity secured by repeated readings the difficulties will diminish if not disappear.

It is a pleasure to acknowledge here my indebtedness to my former colleague, Marian E. Hubbard, professor of Zoölogy in Wellesley College; and to Louise Brown, head of the Science Department in Dana Hall School. Miss Hubbard has not read this book in manuscript and is not to be held accountable for any of its statements, zoölogical or other; but she has made suggestions—especially as regards material needed for the first two chapters—which have been invaluable. Miss Brown is equally free from responsibility for any positions herein taken; at various points, however, she has helped with criticism and advice. Except for the unfailing interest and encouragement of these two friends—their insistence that a text-book on Evidence and Inference is needed—HOW DO YOU KNOW? would not have been written.

E. H.

Wellesley, Mass.
July, 1923.

CHAPTER I

A Crystal and a Cell

If a solution of common salt (sodium chloride) be put into a shallow dish where evaporation may take place rapidly, solid salt following a regular pattern (a cube) will be seen forming in the solution. These tiny salt cubes (crystals), if protected from breakage, moisture and heat, remain unchanged indefinitely. The crystal once formed neither moves nor grows; it does not take food nor does it die; it has especially that property which we call saltiness, and if we pulverize or dissolve the crystal it remains salt. Various other substances crystallizing out of their soluble form are less fragile and far less susceptible to changes in moisture, heat, etc., around them. Quartz, garnet, diamond, are examples; but the quartz, garnet, and diamond crystals all resemble salt crystals in that they do not take food, they do not grow, and they do not die.

Sodium chloride ($NaCl$)[1] is a compound of two elements: sodium a grayish white metal, and chlorine, a yellowish green gas corrosive for organic substances. An atom of sodium unites chemically with an atom of chlorine and the result is a molecule of the compound, sodium chloride, possessing properties wholly different from those of either sodium or chlorine. Chemists formerly supposed that the sodium atom has its own peculiar properties or char-

[1] Na is the chemical symbol for *natrium,* another name of sodium.

acteristics which distinguish sodium from all other elements; and likewise each element was regarded as composed of its own characteristic atom. But further and more recent experimental study justifies the conclusion that the atom is not the fundamental unit of matter, chemically viewed; nor has any atom peculiar properties so that a sodium atom, an iron atom, an oxygen atom, and so on, are all unlike. An atom is believed to consist of a nucleus and electrons revolving around it, very much as planets revolve around their sun; and an atom of one element differs from that of another element merely in the number of electrons which it contains. Thus the sodium atom has 11 electrons, that of chlorine has 17, of oxygen 8, of hydrogen 1, of iron 26, and so on. The now famous element, radium, has an atom of 88 electrons while the uranium atom has 92, the greatest number of all.

In the development of this planet much chemical action has taken place. Compounds have been formed, then broken down with other compounds appearing in their stead—these phenomena depending on circumstances of heat, moisture, pressure, etc. In the course of such changes a complex substance came to be formed, probably in the sea, containing not merely two or three elements, but from twelve to eighteen. This substance, called *protoplasm,* is that out of which all organic forms have arisen. It is in every way unlike a mass of crystals —being formless, jelly-like, unstable, and mobile, with a *cell* as its unit, rather than an atom or a molecule. (A cell is a small mass of protoplasm

containing a nucleus). Cells of two types early appeared: those capable of assimilating raw material, that is, of taking into their structure as food either elements or simple compounds; and others which could only use material which had first been assimilated—worked over, so to speak—by cells of the first kind. This difference between the two classes affords one of the fundamental distinctions between plants and animals. No animal can use as food any material which has not been first digested by a plant or some other animal.

The cell though very small is yet sufficiently complex and—doubtless because of its complexity—tends to take to itself through chemical action further supplies of those substances which it already contains. The substances are strictly speaking food, and because it is fed the cell grows until it breaks into two parts. These parts in turn assimilate food and grow. Reproduction thus ordinarily takes place by binary fission, though two or three modifications of this form exist.

The necessary elements which appear in combination in every cell are: oxygen, nitrogen, carbon, hydrogen, sodium, potassium, phosphorus, sulphur, calcium, magnesium, iron, chlorine (12). In addition to these, silicon, fluorine, bromine, iodine, aluminum, magnesium, occur in some cells.

The cell is so complex and so liable to break down that its surroundings make a great difference to it; whereas, surroundings make no difference to the salt crystal provided—as before remarked—that the crystal is kept safe from whatever might break

it or dissolve it or overheat it. However the salt molecule behaves, or whatever happens to it, we do not describe it as alive; it has no capacity for growth, or need of material to replace used up material; that is, it does not need food, it is not an organism.

And not only does the organism—whether consisting of a single cell (unicellular) or associated cells (multicellular)—require food for its maintenance, thus reacting chemically to chemical substances; it also reacts to heat, light, electricity, water, gravity and other pushes and pulls. All these circumstances in its surroundings are marked by the general term *stimulus,* while *irritability* is the capacity of reacting to stimuli. By *reaction* we mean behavior on the part of the organism different from what it would have been if the stimulus had not been present.

One unicellular creature of great interest is the Amoeba. It varies in size from 0.1 to 0.3 of a millimeter across, and if carefully watched it is discovered to gradually change its shape and also to change its position though with extreme slowness. It can also be caught taking its food—certain foreign particles of organic nature—though it has no special mouth. The amoeba is an independent animal cell; the protoplasm of which it is composed possesses potential energy (energy of position) due

Note. Study of the amoeba is so instructive that the reader should get a full account of this primitive animal from some such text on zoölogy as Parker and Haswell's; and if possible this reading should be supplemented with observations of specimens taken from the slimy deposit at the bottom of pools of rain-water and placed under a microscope.

to its complex chemical composition. When the creature moves, however slowly, some of this energy is changed into kinetic energy (energy of motion); this means the breaking up of some of the complex chemical ingredients of which protoplasm is composed into simpler ones; that is, the protoplasm is being used up and the creature must have food in order to renew the protoplasm; in other words, to gain a new store of potential energy through chemical action.

Regarding the relation of the cell to higher organisms one physiologist writes: "All the higher animals and plants, when submitted to microscopic examination, are seen to consist of structural units which are spoken of as cells. In each organ we find a mass of these cells closely resembling one another in all respects, and we may therefore regard the function of any organ as the sum of the functions of its constituent cells. . . . The cell is therefore the physiological as well as the structural unit."[1]

Dismissing for the moment our drug-store conception of a sponge let us consider sponges at home —"plant-like, fixed, aquatic Metazoa, all, with the exception of one family, inhabitants of the sea." G. H. Parker states: "Sponges are such inert organisms that their membership in the animal series was for a long time unsuspected." Study of their behavior shows them to "represent that stage of evolution in which a primitive type of muscle tissue has made its appearance, unaccompanied with nervous elements. . . . They mark the beginnings of the neuromuscular mechanism in that they possess the

[1] E. H. Starling, *Principles of Human Physiology*, p. 13.

original and most ancient of its constituents, muscle, around which the remainder of the system is supposed subsequently to have evolved."[1] Professor Parker concludes an account of certain observations and experiments with the statement: "Although of the three identifiable elements of the neuromuscular mechanisms of animals, sense organs, central nervous organs, and muscles, sponges possess only muscles, they nevertheless exhibit among their many activities neuroid transmission, a sluggish form of transmission that may be considered the forerunner of nervous activities, and in this sense may represent the germ from which has sprung the real nervous conduction of the more complex animals."[2]

Passing to the consideration of Coelenterates—creatures of low organization yet more obviously animal than the sponges—the investigator already quoted says: "Compared with such sluggish responses as those shown by sponges, the movements of hydroids, coral animals, sea-anemones, jellyfish and other coelenterates are quick, though the movements of these animals are in turn slow compared with those of vertebrates and especially of insects. This quickened rate of response, which distinguishes the coelenterates from the sponges, is associated with the fact that the coelenterates possess not only muscles but also nervous organs in the form of simple sensory surfaces by which their muscles are called into action more quickly than they would be by direct

[1] G. H. Parker, *The Elementary Nervous System,* p. 49.
[2] *Opus cit.,* p. 75.

stimulation."[1] In connection with this important gain made by the coelenterates we should note a comprehensive truth as stated by another authority: "Irritability and conductivity, . . . two of the fundamental properties of protoplasm, reach their maximum development in the highly differentiated tissue of the nervous system. Indeed, it is in response to the need for increased sensitiveness to stimuli and for better transmission of the impulses aroused by them that the nervous system has developed and been perfected in the long process of evolution which has culminated in man."[2]

The advantage to the animal of possessing cells especially sensitive to stimuli in its surroundings would be followed by: (a) persistency rather than disappearance of these cells; and by (b) a development and increasing complexity among such cells as the animal has varied in other respects, anatomically and physiologically. These sensory cells and muscle cells are both built up out of protoplasm, but the former having a higher degree of sensitiveness this primitive cell differentiation was naturally followed by a differentiation in function.

The story of evolution from the lowliest unicellular organism to the highest animal, man, is largely a record of the nervous system. At first these nervous portions showed no greater condensation in any special region or regions of the animal body, but formed what is called the *nerve-net*. It originally served, and still serves, the need of most elementary

[1] G. H. Parker, *The Elementary Nervous System*, p. 76.
[2] S. W. Ranson, *The Anatomy of the Nervous System*, p. 17.

organisms; but as higher forms of life developed from lower ones the nervous system became more and more elaborate. A sensitiveness all over the exterior of the organism—the mother sense of touch—early exhibited an emphasized sensitiveness at various spots. Some of these spots or small tracts responded to one kind of stimulus and other spots to a different kind. Thus the actual evolution of the eye is now figured out to be as follows: First, the appearance of little pigment spots—crowded groups of cells—which absorbed more light than neighboring cells. Animals with such spots, being able to distinguish between light and darkness, would have an advantage over other creatures not thus equipped. Again, individuals appearing with these pigmented spots sunken in pits, thus securing still greater condensation of sensitive cells, would be superior to others. Thirdly, such a pit becoming partly closed, the cavity would be filled with water—since the animals in question were aquatic—and the physical effect was the formation of a faint image on the sensitive surface within. The "pin-hole camera" illustrates the action of this eye, examples of which are actually found in animals living to-day. Protection from injury would obviously be an advantage and such protection has come about in two ways: A thin film of transparent skin grows over the opening and closes it; and then, since water from the outside can no longer enter, the cavity is filled with a semi-liquid secreted by certain cells of the body. As the next step this semi-liquid passes to a more solid state with curved surfaces. It becomes, in fact, a lens which

focuses the rays of light upon the sensitive surface behind it. The Eye is still further improved when an opaque fold (iris) grows, shutting out the most oblique rays, with the result that a clearer image is formed. With a few additional minor features, the eye in its highest known development is reached.[1]

At every step in the evolution of the eye, from a simple and inefficient type to an elaborate and improved one, development has followed the properties of light. That is, a useful variation has been one in accord with the seeing needs of the organism; and good seeing depends not only on stimulus but also on a physical passageway consistent with the properties of light. Such variations have survived and accumulated until the eye of man and many other animals including birds is, strictly speaking, an optical instrument.

As regards the origin of the color-sense Wallace remarks: "The primary necessity which led to the development of the sense of color was probably the need of distinguishing objects much alike in form and size but differing in important properties, such as ripe and unripe or edible and poisonous fruits, flowers with honey or without, the sexes of the same or closely allied species. In most cases the strongest contrast would be the most useful, especially as the colors of the objects to be distinguished would form but minute spots or points when compared with the broad masses of tint of sky, earth or foliage against which they would be set."[2] A more recent

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[1] Adapted from H. W. Conn, *The Method of Evolution,* p. 26.
[2] Alfred Russell Wallace, *Darwinism.*

student, Collins, attaches great importance to the arboreal life of primitive man's forebears and his anthropoid kin. "The perception of small colored objects is essential for the existence of arboreal animals which live mainly on fruits that they pick up with their hands." We are therefore not surprised to find that the color-sense of monkeys is much more highly developed than that of dogs. Dr. Collins claims in conclusion: "The changes in the visual organs of mammals, produced by the adoption of arboreal life, increased both the range and accuracy of their powers of observation for natural phenomena. It was in this way that the portal became opened for the evolution of the mental faculties of memory and inference—faculties which enabled man's anthropoid ancestors, on descent from the trees, to subdue their foes, to become successful hunters, and to adopt an omnivorous diet."[1]

The history of the organ of hearing is, in like manner, marked by successive steps beginning with small tracts more sensitive to sound waves than the rest of the body surface—each new feature persisting if it was one of advantage—until the complicated ear was formed. Similarly, the organs of taste and smell have arisen as local differentiations of small tracts originally marked by cells sensitive in the way denoted by tasting and smelling.

Organized bodies began early to take on a lengthwise structure. If a line, XY, be supposed drawn parallel to a lengthwise body, movement was, as a

[1] E. Treacher Collins, *Arboreal Life and the Evolution of the Human Eye,* p. 106.

rule, from, let us say, X to Y; not indifferently from X to Y and from Y to X. That is, the animal became a fore-and-aft organism. Of two animals one with sensitive spots indifferently divided between the two ends and the other with such spots grouped at one end the latter would doubtless have an advantage due to coöperation among these spots. Elementary eyes and ears worked together more readily by being near each other. Further, and of still greater consequence, such animals of the second group as had these regionally associated spots at the anterior end rather than the posterior would have an advantage over the others in that the needs of the organism were more effectively served: warning would be given of approaching danger or food. The advancing end thus became the head end; it bore the brunt of stimuli, and sensitive spots at this forward end received more cultivation, so to speak, than did any which may have appeared elsewhere. Hence the sense organs are assembled in the anterior end of the body. The brain, the greatest organ of the central nervous system, has also developed there close to the sense organs which give access to the brain.

The sense organs are the approaches to the brain; through them, as through gateways, the exterior environing world connects with the brain, and through the brain behavior is determined. Coöperating with the special sense organs and likewise nervously connected with the central nerve organs is the diffused sense of touch. That it has been of unfailing advantage to creatures at every stage of development

is too plain to need the argument based on persistence.

It may be said here—what will appear as we proceed—that, fixing attention on the vertebrate mammal, man, the nervous system is the all-important one. In a very literal sense the rest of the body has the care of the nerves. This body, elaborately built up on a bony framework, with muscles, tendons, fatty parts, skin, mucus membrane, organs for purifying the blood, organs for the treatment of the food that the body may be nourished—this whole complex coöperatively organized body is for that part of it known as the nervous system. This system no doubt pays back all its debt to the others, but its functioning is much more than one of honest return of good for good—or evil for evil. "The nervous system, to be sure, is embedded among the other organs of the body, and the environment thus provided influences profoundly its condition and action; but what is meant by individual personality, acuteness or dulness of sense, quickness or slowness of action, temperamental traits, such as a gloomy or bright disposition, incapacity, shiftlessness, honesty, thriftiness, or sweetness, are all in the strictest sense functions of the nervous system."[1] The superior importance of the head, which carries the cerebrum, is clearly indicated by Sherrington who writes: "The head is in many ways the individual's greater part. It is the more so the higher the individual stands in the animal scale. It has the mouth, it takes in the

[1] G. H. Parker, *The Elementary Nervous System*, p. 16.

food, including water and air, it has the main receptive organs providing data for the rapid and accurate adjustment of the animal tissue to time and space. To it the trunk, an elongated motor organ with a share of the digestive surface, and the skin, is appended as an apparatus for locomotion and nutrition."[1]

Modern human physiology recognizes not merely the long known special senses on which stimulus acts —those which furnish us with sensations of sight, sound, smell, taste, and touch; it finds that properly several of these should be subdivided. Thus the sense of touch yields prominently sensations of pressure (especially in the form of weight) and of temperature (heat and cold); so that we have at least six exterior senses: sight, hearing, taste, smell, temperature, and pressure, subject to stimuli from the outside world. The last two have no such localization as the first four, though the hand is so generally used to examine an external body as regards weight and temperature that we are inclined to forget that other parts of the body—the shoulder, the foot, the top of the head, etc.—might be used. A man without a spring balance or other weighing device "hefts" an object with his hand to learn its approximate weight. A woman wets her finger and quickly touches the flat-iron to find its temperature for the purposes of ironing.

Again, the organ of vision might well be regarded as several specific senses organized as one. Thus

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[1] C. S. Sherrington, *The Integrative Action of the Nervous System,* p. 350.

through this organ we have sensations of color, of shape, and of motion. These are distinct and not interchangeable—unless we say that motion is readjustment of an object in its framework of objects, thus varying the shape of the figure made by the moving object and its reference objects. If the details of shape are known by differences in color—at least in shades—of the component parts, namely, the moving and unmoving objects, then the resolution of sight impressions into color, shape, and motion, seems unwarranted; there is only color. But the phenomenon of color-blindness must convince us that the color element in vision far exceeds the needs of shape (form) and motion. The eye of man and other animals might have developed without sensitivity to that which appears on a screen when a glass prism is held in a beam of sunlight in front of the screen.

Further, "In the odor sensations we distinguish many different qualities, each recognizable at the time that it is experienced, but their characteristics are so fugitive that so far it has not been possible to name them or group them in any satisfactory way."[1] These fugitive odor sensations are analogous to the series of spectral colors—with this advantage as regards the latter: a permanent external record of color may be made and, more than that, the ether wave-length to which any spectral color is due may be measured and stated as a fractional part of a millimeter. But how make a permanent ex-

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[1] W. H. Howell, *A Text Book of Physiology,* p. 272.

ternal record of the fragrance of heliotrope, for instance; how name it except by saying "heliotrope," or "something that smells like heliotrope"—perhaps beeswax; but what does beeswax smell like?

Many adjectives have been employed to describe tones and qualities of tones; yet sound sensations lag far behind those of sight in their susceptibility to accuracy of treatment. The phonograph proves indeed the possibility of external record of sounds; and its actual record of the human voice both in speaking and singing, and of the violin, testifies to the marvelous quality of this mechanical device; yet the phonograph as a recorder gives no promise of ever rivaling in its achievements the phenomenon which takes place when a prism of glass is held in a beam of sunlight.

The sense of taste, so singularly variable qualitatively among different individuals, was perhaps one of the very early methods of becoming acquainted with the environment. Children are given to tasting the world. Leaves, grass, bark, gums—over and above every sort of nut and berry and small seed—go into their mouths either that they may learn something about them or that perchance they may find something good to eat. The learning, if it be such, is carried on by eating, though it may be merely an expression of the instinct of curiosity.

In addition to all these primary external senses and the sub-senses into which they are resolvable a second class, that of internal senses, exists. "Through these internal senses we acquire a knowledge of the condition of our body, and perhaps also

a knowledge of ourselves as an existence or organism distinct from the outside world."[1] That is, consciousness holds an awareness of body sensations, some of well-being, others of ill-being. The aggregate of well-being sensations, if persistent, constitutes what we mean by the phrase, "enjoyment of good health." Ill-being sensations, on the other hand, signalize internal injury, disorder, or disease. These signals of good and of evil, physiologically speaking, are of evident advantage to the organism as a whole, and have come into existence and persisted in response to need.

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[1] W. H. Howell, *A Text Book of Physiology,* p. 273.

CHAPTER II

From Tropism to Intelligence

The problem of the eye has only been solved by careful observation and examination of a series of animals exhibiting this sense organ in various stage forms. The same kind of observational and experimental study in the laboratory discloses the steps in the evolution of the nervous system, including that aspect of it called psychic. Brain behavior, or—if we prefer another term—mind behavior, can only be analyzed by tracing characteristic responses to stimuli through a series of animals in the order of their development. It is a task for the student of comparative physiology of the brain and the corresponding comparative psychology. This book, intending to deal practically with only one feature of mind behavior—the acquirement of knowledge—leaves the reader to consult the comprehensive treatises, the work of physiological experts, for accounts of investigations to date. However, enough reference to these investigations must be made to indicate the origin and development of intelligence in order to arrive at a knowledge of the nature of knowledge itself.

The acts of the human animal find explanation—their only explanation—in the gradatim development of preceding animals, man's ancestors taken in chronological order. To begin with, "the direct motor response of an animal to external stimulus is

known as a *tropism,* from the Greek word meaning to turn."[1] These stimuli have been mentioned in the preceding chapter. Jennings states: "We find that the simple naked mass of protoplasm reacts to all classes of stimuli to which higher animals react (if we consider auditory stimulation merely a special case of mechanical stimulation). Mechanical stimuli, chemical stimuli, temperature differences, light, and electricity control the direction of movement, as they do in higher animals. In other words, Amoeba has some method of responding to all the chief classes of life conditions which it meets."[2]

This same investigator, studying comparatively the behavior of the Protozoa which are unicellular and without a nervous system and the Metazoa which are multicellular and with a nervous system, concludes: "All together, there is no evidence of differences of fundamental character between the behavior of the Protozoa and that of the lower Metazoa. The study of behavior lends no support to the view that the life activities are of an essentially different character in the Protozoa and the Metazoa. The behavior of the Protozoa appears to be no more and no less machinelike than that of the Metazoa; similar principles govern both."[3]

The physiologist, Verworn, discussing nervous operation in animals having a nervous system, points out that in the simplest case of such animals three different cells are concerned. "One cell, the sensory

[1] Margaret F. Washburn, *The Animal Mind,* p. 57.
[2] H. S. Jennings, *Behavior of the Lower Organisms,* p. 19.
[3] H. S. Jennings, *Behavior of the Lower Organisms,* p. 263.

cell, receives the stimulus; from this a centripetal nerve path conducts to a central cell, the ganglion cell, and from here a centrifugal nerve path conducts to a cell that performs the reaction, the motor end cell."[1] Thus, "In the lowest definite nervous system with which we are acquainted, namely, that of the jelly-fish, all three types of cell, the sensory cell, the reactive or central cell, and the motor cell, are already developed and have undergone among themselves a considerable degree of differentiation."[2]

This for invertebrates. Verworn continues: "In vertebrates, so far as the conditions are known, a fourth cell at least is interpolated in the arc, since in place of one ganglion cell at least two are present; one of which receives the stimulus from the sensory cell and conducts it to the other, while the other transfers the impulse to the motor end cell."[3] Generalizing this with a symbolic notation and an implied diagram we have:

X = stimulus;
A = nerve cells receiving stimulus;
A——B = sensory nerve impulse;
B . . . C = transfer of nerve impulse;
C——D = motor nerve impulse;
E = muscles;
Y = behavior.

The series from X to Y is what Verworn calls a reflex arc. The final reaction Y (behavior), pre-

[1] Max Verworn, *General Physiology*, p. 576.
[2] E. H. Starling, *Principles of Human Physiology*, p. 290.
[3] Max Verworn, *General Physiology*, p. 577.

ceded by the circumstances in the order indicated, is known as reflex action.

In describing the parts of this mechanism Starling says: "Every skeletal muscle is connected with the central nervous system by nerve fibres, some conveying impressions from the muscle to the center, the others acting as the path of the motor impulses from the center to the muscle. These latter—the motor nerves—end in the muscular fiber itself, by means of a special end-organ—the motor end-plate."[1]

With this brief notice of tropism and reflex action we pass to a third form of behavior: instinctive action.

Instincts are native tendencies to uniformly recurring modes of behavior. Instinctive action has the appearance of habit; but habits must be formed; whereas instinctive action seems to initiate itself in response to stimulus, without trial effort, without experience, and without instruction; that is, without modification due to the individual history of the animal, yet a repetition of ancestor behavior. The following illustration serves: A collie, born in a region destitute of sheep, was taken when quite young to a distant State. His new home was at the edge of a village; here, also, he never saw a sheep. In early summer a hen's small coop was placed on the lawn near the garden; the hen was tied outside while her brood of about a dozen two-weeks-old white chicks was free to range over the lawn and

[1] E. H. Starling, *Principles of Human Physiology*, p. 183.

in the garden. The dog, Eric, now some eleven months old, took it upon himself to herd these chicks. When they strayed even ten or fifteen feet away he would walk slowly around them, waving his tail, until they returned to some place near the hen; he would then lie down with his forepaws crossed in front of him, facing the hen and chicks. The hen was very quiet and made no objection to this unusual assistance. He kept this up for two weeks or more—until the hen was moved. It should be added that during the same time another hen was tethered near, but Eric took no responsibility for her brood.

Professor Loeb writes as follows: "The discrimination between reflex and instinctive actions is chiefly conventional. In both cases we have to deal with reactions to external stimuli or conditions. But while we speak of reflex actions when only a single organ or group of organs react to an external stimulus, we generally speak of instincts when the animal as a whole reacts. In such cases the reactions of the animal, although unconscious, seem directed to a certain end. A fly acts instinctively when it lays its egg on objects which serve the hatching larvae as food. We call the periodical migrations of animals instinctive. We call it instinctive when certain animals conceal themselves in cracks and crevices where they are safe from persecution. But the purposeful character of instincts cannot be used to distinguish them from reflexes, as a great many of the reflexes are purposeful, for instance, the closing of the eyelid if the conjunctiva be touched. On the

other hand, it cannot be said that every instinctive action is purposeful, for instance, the flying of the moth into the flame."[1]

Loeb's experimental analysis of instinctive actions reduces many of them to tropisms of various kinds; thus "the tendency of many animals to creep into cracks and crevices has nothing to do with self-concealment, but only with the necessity of bringing the body on every side in contact with solid bodies." But this investigator also points out that in many cases instinctive action is complicated by the influence of associative memory—which breaks down any sharp distinction between instinctive action and "intelligent" action. Thus Loeb remarks: "The periodic depth-migration of marine animals is a simple case of instinctive migrations, while the migrations of birds or the accomplishments of the carrier-pigeon seem to be complicated by memory. It seems to be certain that the carrier-pigeon finds its way back by its visual memory of the locality from which it started. In the same way the migrations of birds may be determined, if it is true that migrating birds return to their old nest."[2]

What is intelligent action—a fourth form of action to which reference has just been made? Reviewing the symbolism offered on page 13 it is now to be noticed that with a given stimulus, X, that is, with X a constant, as mathematicians would say, any variation in Y must be due to other factors, *b, c,* etc. among the B, C, cells. More fully stated, the func-

[1] J. Loeb, *Comparative Physiology of the Brain,* p. 177.
[2] J. Loeb, *Comparative Physiology of the Brain,* p. 196.

tion of B, C, may become more than merely one of adjustment of sensory impulse for transference; it may take on the additional office of storage and modification. Upon receipt of a sensory impulse refined physiological changes may take place: the sense impress is recorded in the nerve structure as a memory; the assemblage of such records at length forms the *associative memory,* regarding which Loeb says: "By associative memory I mean the two following peculiarities of our central nervous system: First, that processes which occur there leave an impression or trace by which they can be reproduced under different circumstances than those under which they originated. . . . The second peculiarity is, that two processes which occur simultaneously or in quick succession will leave traces which fuse together, so that if later one of the processes is repeated, the other will necessarily be repeated also. The odour of a rose will at the same time reproduce its visual image in our memory, or, even more than that, it will reproduce the recollection of scenes or persons who were present when the same odour made its first strong impression on us. By associative memory we mean, therefore, that mechanism by means of which a stimulus produces not only the effects which correspond to its nature and the specific nature of the stimulated organ, but which produces, in addition, such effects of other causes as at some other time may have attacked the organism almost or quite simultaneously with the given stimulus."[1] Loeb immediately adds: "The chief

[1] *Opus cit.,* p. 213.

problem of the physiology of the brain is, then, evidently this: What is the physical character of the mechanism of the associative memory? . . . The answer to this question will probably be found in the field of physical chemistry."[1]

Another physiologist writes: "The association areas may be regarded therefore as the regions in which the different sense impressions are synthesized into complex perceptions or concepts. The foundations of all knowledge are to be found in the sensations aroused through the various sense organs; through these avenues alone can our consciousness come into relation with the external or the internal (somatic) world, and the union of these sense impressions into organized knowledge is, according to Flechsig, the general function of the association areas. This function of the association areas is indicated by the anatomical fact that they are connected with the various nerve centers by tracts of association fibers, suggesting thus a mechanism by which the sense qualities from these separate sense centers may be combined in consciousness to form a mental image of a complex nature. . . . In the association areas our memory records of past experiences and their connections are laid down in some, as yet unknown, material change in the network of nerve cells and fibers. Here, as elsewhere in the nervous system, it may be supposed that the efficiency of the nervous machinery is conditioned partly by the completeness and character of training,

[1] *Opus cit.*, p. 214.

but largely also by the inborn character of the machinery itself."[1]

As implied above by Loeb the seat of associative memory is the brain; but the brain falls into two main divisions: (a) the brain stem, a prolongation upwards of the spinal cord, including the cerebellum; and (b) the cerebral hemispheres. In man the cerebral hemispheres form a great ovoid mass, exceeding in size all the rest of the brain put together. The whole surface of these hemispheres is deeply convoluted, with a surface covering in the form of a thin sheet of gray matter which follows the convolutions, thereby greatly increasing its surface area. This gray matter covering the cerebral hemisphere is known as the *cerebral cortex;* it varies in thickness from one-sixth to one quarter of an inch. The cerebral cortex is justly called the "master tissue of the body" (Starling), for it is the field of those brain activities which afford the phenomena of personality —ranging from temperament to the intellectual life.

"A comparison of the brain of the dog, ape, and man shows that, while the absolute amount of brain substance devoted to the elementary functions of movement and sensation remains practically the same throughout, in man these areas are, *relatively* to the whole brain, very much diminished in size, the greater part of the brain surface being taken up with the nervous material of the type which is connected with the functions of association involved in

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[1] W. H. Howell, *A Text Book of Physiology*, p. 224.

the higher processes of reflection, intelligence, and volition. If we draw still lower animals into the sphere of our observations, we are enabled to form some idea of the relative significance of the various elements of the cortex. Thus in an animal, such as the rabbit, the polymorphous layer is three times the thickness of the pyramidal layer; whereas in man, with an infinitely greater range of reaction, it is only one-third of the thickness of this layer. If we roughly assign a function to each of the types of cells found in the cortex, we may say that the pyramidal cell layer is generally associative in functions. The large pyramidal cells of Betz are motor; the granular layer is sensory, while the polymorphous layer presides over the lowest cortical functions, such as those concerned in the getting of food, the sexual instincts, and so on."[1]

The results of prolonged and painstaking laboratory study of the brain in a series of type animals, disclosing their successive modifications and developments, do not permit us to doubt that the brain, in common with all other parts of the body, must trace its ancestry back to primitive forms of animal life. The functioning of the human brain cannot be understood except through consideration of the nervous system in man's immediate and remote animal kin. Now, as Starling points out, "in an animal possessing cerebral hemispheres it is impossible to foretell with certainty what particular reaction may be evoked by any stimulus."[2] What is the meaning of

[1] E. H. Starling, *Principles of Human Physiology*, p. 432.
[2] *Opus cit.*, p. 433.

this uncertainty? That is, how shall we account for the qualitative and quantitative variation in Y (p. 22) with a given X? The sensory portion of the nervous system, however elaborate in its ramifications, is essentially a means of transference of sense impresses; it does not add to, or subtract from, these sense impresses en route. And a similar task, that of transference, falls to the extended motor portion. In other words neither the sensory system nor the motor is responsible for variation in reaction Y. As already noted, p. 23, when the impulse conveying the sense impress arrives at B, C, the impress is registered there and may go no further—for the time being. This record is the unit of experience. The accumulation of such records—physical changes in the cerebrum—becomes an interlocking combination to modify behavior. If we knew every detail of the composite record there would be no difficulty in "foretelling with certainty what particular reaction may be evoked by any stimulus." When a person's sense organs are subjected to a stimulus which results in a reasonably prompt change in behavior he "acts in view of." In view of what? If his action is not an involuntary reflex, or habitual, or instinctive, he acts, strictly speaking, in view of his life's experience plus this latest addition; that is, in view of the vast aggregate of recorded sense impresses together with all material elaborated from those impresses. No doubt some of this store of experience is more effective than the rest, but probably none of it is wholly ineffective.

Besides this change in behavior which is primarily

induced by the special immediate stimulus there is much behavior which apparently lacks a definite and closely preceding stimulus. This means, however, that the sense impress is merely separated from the behavior reaction by an interval of time long enough to obscure the connection. A June thunder shower finds weak spots in the roof and you decide that not later than November the roof must be re-shingled. In October you bargain for shingles and hire carpenters. Stimulus in the form of a sense impress of a leaking roof has bided its time for several months, and the reaction at length takes place.

The connection between stimulus and behavior is more readily studied, however, when the time interval is short. To illustrate: I feel a draught on the back of my neck—a new sense impress due to a change in my environment. How long have I been exposed to this draught? It is the readiest way for me to catch cold—miserable ailment—something must be done. My first reaction is to look around with the purpose of discovering where that current of air comes from. A window is open behind me; I left it open, myself. Since doing so either the wind has risen or it has shifted to the southeast; for I "recall" that it did not blow in an hour ago when I opened the window. Rising to close the window can hardly be said to be an impulsive act—too many records from associative memory have come forward to allow it to be called that; but before actually moving the sash one of my recent records steps in to modify my behavior: I have lately read that in case of lack of oxygen associative memory first disap-

pears; indicating that the cerebral hemispheres are most sensitive to a reduction in the supply of oxygen. The cerebral cortex—it is too precious to be maltreated. My actual behavior is to shift my books and papers to the opposite side of the table. If another person were present he could not have predicted with any certainty what my behavior, with that windy stimulus, would be; because he does not know my whole associative memory; he knows very little of it—even if he is well acquainted with me. If I do not speak and explain he cannot possibly guess the part played in the determination of my behavior by Professor Loeb's account of Speck's experiments, given on page 255 of *Comparative Physiology of the Brain.* My action was "intelligent," not because I changed my seat instead of closing the window, but because experience—recorded memories—entered the case.

An answer is now suggested to the question: What is intelligent action as distinguished from tropisms, reflexes, and instinctive action? Intelligence, manifesting itself in intelligent action, is conditioned upon experience—experience being the accumulated store of associative memory. The conditions for the origin and development of intelligence have been such advantageous variations—both as regards quantity and quality—of the gray matter of the cerebrum as might fit this tissue to serve as an accumulator as well as an adjustor; that is, to render associative memory possible.

The power to retain a memory of an experience is sometimes spoken of as the ability to form images.

Here the term "image" must not be limited to the image of the physicist; it denotes the re-forming, through memory, of impresses received by any and all of the sense organs. For example, without any immediate auditory sense impress a vague strain of music seems to float out of memory's stores into consciousness. What is it? Where have I heard it? Presently the auditory image becomes distinct —I have it. The music is Beethoven's *Minuet* in G.

As we have just seen, voluntary (intelligent) action is modified, when not wholly determined, by recalled sense impresses and their products. But while much action takes place with no apparent stimulus in the present environment, it is also the case that much, probably most, of remembering does not result in physical action—at least not in immediate action; it may be mere reverie without order or sequence, or it may be a review of a portion of one's physical or mental experiences without any special object such as interpretation or new combinations of this old stored material; and there is thus no occasion for immediate action known as change in behavior. It should be noted that in our waking hours we are continuously "behaving." Change of action is one behavior merging with more or less rapidity into another.

The gradual appearance and growth of association areas means a growth in delicacy and complexity of the cerebral material and structure, with accompanying higher forms of intelligence. The nature and manifestation of these higher forms will be discussed in a later chapter. At this point it is

only necessary to remark that a combination of images results in an *idea*.

Intelligent behavior, as above seen, occurs in view of such past experiences as bear—more or less immediately—on the behavior of the moment in question. Besides these there is a persistent foreground of many experiences. An individual may be asleep, or be suffering from a blow on the head, or be in a delirium due to sickness, or be under the influence of an anaesthetic; when he "comes to himself"—either by awakening, or recovering from the injury or sickness, or escaping from the anaesthetic—he identifies himself with the self of yesterday, last week, last year, not by any particular experiences of those past times, but by a persistent matrix of experiences in which those definite experiences were embedded. That is, the permanent cerebral network immediately reappears; and its reappearance is indicated by that common expression, "coming to himself." What had happened in each case was an interruption of the activity of associative memory. This network of cohering experiences, once instituted in the associative tract, persists until certain changes in cerebral conditions again induce its disappearance. Death is merely a final disappearance accompanied by other physical mal-conditions of heart, lungs, etc. This persistent matrix or plexus, network, foreground—name it as we will—developed in the association area of the cerebral cortex, is what is usually called *consciousness*. Like intelligence, with which it is so intimately associated if not largely identical, consciousness is thus a property of associative mem-

ory, arising when associative memory reaches the necessary degree of content and complexity. And as that memory is an accumulated record, a deposit—so to speak—of sense impresses and their products, the fundamental relation of consciousness to sense impression is apparent.

Sherrington, one of the master investigators of the nervous system, says: "Associative memory would seem to be a postulate of the very existence of perception. Where even simplest ideas are not, there cannot be consciousness. Animal movements that are appropriate not only for an immediate but also for a remote end indicate associative memory. The approach of a dog in answer to the calling of its name, the return of an animal when hungry to the place where it has been wont to receive food, such movements may be taken as indicative of consciousness since they indicate the working of associative memory."

Discussing the nature of consciousness Professor Loeb writes: "The view that consciousness is only a metaphysical term for the phenomena determined by the mechanisms of associative memory finds support in the results of experiments on higher animals. Extirpation of the cerebral hemispheres causes complete loss of the associative memory. After this operation nothing remains that could possibly be interpreted by the metaphysicians as a phenomenon of consciousness."[1]

Referring to the studies of Ernst Mach, Loeb

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[1] J. Loeb, *Comparative Physiology of the Brain*, p. 236.

says: "Mach has pointed out that the consciousness of self or the ego is simply a phrase for the fact that certain constituents of memory are constantly or more frequently produced than others. The complex of these elements of memory is the "ego" or the "soul" or the personality of the metaphysicians. To a certain extent we are able to enumerate these constituents. They are the visual image of the body so far as it lies in the field of vision, certain sensations of touch which are repeated very frequently, the sound of our own voice, certain interests and cares, a certain feeling of comfort or discomfort according to temperament or state of health, etc."

Karl Pearson calls attention to the important fact that "we recognize consciousness in our individual selves, we *assume* it to exist in others."[1] Similarly, W. K. Clifford says: "When I come to the conclusion that *you* are conscious, and that there are objects in your consciousness similar to those in mine, I am not inferring any actual or possible feelings of my own, but *your* feelings, which are not, and cannot by any possibility become, objects in my consciousness."[2]

We do not find, nor should we expect to find, any abrupt transition from animals without consciousness to animals with it. As Starling remarks: "From the fact that the reactions of the higher mammals are evidently determined, not by immediate impressions but largely by stored-up impressions of past

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[1] K. Pearson, *Grammar of Science,* p. 58.

[2] W. K. Clifford, *On the Nature of Things-in-Themselves,* p. 72.

stimuli, we credit them also with a certain but lower degree of consciousness. As we descend the scale of animal life, evidence of the existence of consciousness as we know it, rapidly diminishes and finally disappears. . . . Consciousness is, in fact, connected with the possession of a highly developed central nervous system, and its activity is in proportion to the complexity of this system."[1]

Ranson describes the emergence of consciousness in the following language: "Previous experience of the individual, having left its trace in the organization of the central nervous system, alters the character of the present reactions. It is in connection with the neural activity involved in these complex associational processes that consciousness appears—shall I say as a by-product?—at least as a parallel phenomenon."[2]

This understanding of consciousness as of different degrees of activity in different individuals and, indeed, of varying degree in the same individual at different times, must be continually reckoned with in accounting for what we call "mental" differences and growth. More and better "mind" strictly means more pronounced consciousness and larger intelligence, that is, better and richer cerebral cortex.

Consideration of the nature of consciousness properly entails an examination of the idea of volition or of the will—the "freedom" of which is an idea highly prized by those who refuse to face the evidence of the protoplasmic origin and the gradual

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[1] E. H. Starling, *Principles of Human Physiology,* p. 9.
[2] S. W. Ranson, *Anatomy of the Nervous System,* p. 23.

development of man. Maurice Parmelee, in an admirably lucid passage, writes: "So far as anything like will or volition exists at all it is a characteristic of consciousness and probably should be limited to self-consciousness. Volition manifests itself when the idea of an act, which has grown out of memory images of the act, and other contents of the memory influence behavior. Thus a stimulus to a certain action may be received, and the act will be performed unless the contents of the memory consciously inhibit it, in which case the volition will have been exercised. If the inhibition is unconscious as the result of habit, it cannot be regarded as volitional. Or the idea of a certain act may be aroused and serve as a stimulus to its performance, in which case a volitional act will have been performed. In each case of a volitional act the stimuli to action are either inhibited or reënforced by the contents of memory and other characteristics of the individual, and the process is accompanied by consciousness, so that there frequently arises the illusion that the act is determined by the self, independent of external forces."[1]

Hobhouse, using language somewhat less technical, says: "The will is not to be regarded as an additional impulse, or as a force existing outside impulses and operating upon them. It is rather the system or synthesis of impulses, the broad practical bent and tendency of one's nature. . . . It is quite possible that even in animal life, when there is a

[1] M. Parmelee, *The Science of Human Behavior,* p. 311.

conflict of desires, that one tends to prevail which is most intimately bound up with the animal's whole mode of life. . . . The new development is merely that those broad tendencies of the character which before operated, if at all, obscurely and unconsciously, have now a definite conception to guide them."[1]

As a homely illustration of the thousands of times that we thing our action is voluntary, i.e., willed, the following serves: The milkman has left a bottle of milk at the door; probably he has, though I have not seen or heard him; it is past his usual time of coming. It is zero weather; I reason that certain undesired consequences will follow unless I bring that bottle of milk in. I rise and go to the door and get it. Did I "will" freely to do so just before I did it? A careful study of the two quotations in the preceding paragraphs will conduct to the correct answer.

As bearing directly on the question of will to behave, one may note with profit the words of a student already quoted: "The acts of a conscious individual, i.e., one possessing cerebral hemispheres, are determined by his experience. The wider the range of past sense impressions which can be called up and taken into the chain of processes involved in any reaction—the more, that is to say, the individual weighs his acts in the light of past experience—the more fitted will these acts be to his maintenance amid the ever-changing stresses of the environment.

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[1] L. T. Hobhouse, *Mind and Evolution,* p. 313.

In this guiding of behavior by experience man, as well as the higher mammals, may profit also from accumulated racial experience."[1]

If we now inquire, What is mind? there is apparently nothing for it to be except a convenient term for all that is indicated by those other terms, intelligence and consciousness. The physiological changes attending the entire range of phenomena covered by these two terms, when viewed on the reverse, or psychical, side comprise all mental phenomena. The assumption of a mind, or ego, as independent of and above neural physiological phenomena is a speculation which has never been able to marshal any evidence which lifted it out of the speculative stage even into that of hypothesis.

Feelings, including emotions, as part of the contents of consciousness may be described as secondary or reënforcing stimuli, dynamic in quality, in that they often prompt to action. They are by-products of sense impresses, either the impresses of the moment or stored ones, or the elaborated results of such impresses. They differ fundamentally, however, from other psycho-cerebral belongings in that they do not yield *perceptions* (p. 44). Whether they move to action or not, they remain as a pleasurable or painful state in consciousness until they fade away. Since they afford no perceptions they afford no knowledge, for all knowledge is based on perception.

To illustrate the nature of emotion: I see a man

[1] E. H. Starling, *Principles of Human Physiology,* p. 453.

beating a horse, perhaps I also hear the swish and thud of the whip. The sense impresses received through the eye and ear are recorded, but the recording is attended by a painful feeling; it is the emotion of indignation, perhaps of anger, along with pity for the horse. My heart beats somewhat faster; probably my eyes flash; I "feel like" taking the whip to the man; I am "moved" to remonstrate or threaten; perhaps, instead of doing either, I go to find a police officer. If I go into court to testify in the case, I can make the judge and others know—provided they believe what I say—but all efforts to make another feel are so uncertain of success and so irrelevant that I only state the facts; I should be laughed at if I offered to the court a description of my feelings with a view to arousing sympathy; the facts must be left to do that.

Knowledge is objective and hence a matter of common property; but feelings—hope, joy, fear, anger, and the like—are subjective; they are variable and evanescent and while they last they belong in a peculiar sense to the individual experiencing them; they leave traces, however, which compose part of the permanent sum total of one's experiences. I shall "get over" the indignation which stirred me when I saw the horse beaten; I shall not lose my resolution to help the Society for the Prevention of Cruelty to Animals.

Closely related to the notion that feelings are a source of knowledge is the doctrine of intuitional knowledge as "truth that cannot be acquired but is assumed in experience." The meanings of the term

intuition are various and vague; selecting one in harmony with the clause just quoted: "Intuition denotes original self-evident and necessary first principles, both theoretical and practical, and the (primary) consciousness of them."[1] It is sufficient in this connection to point out that the defenders of such a view are obliged to do one or the other of two things: (a) they must make bare dogmatic assertions; or (b) they must give examples of what they regard as intuitive knowledge. In the first case mere assertion, plain dogma, has no place—and deserves no respect—in intellectual life, because it means wiping out the sharp line between ignorance and superstition on the one hand, and on the other those contents of the mind which have been won through attentive examination of Nature and of man as a part of Nature. If the metaphysical philosopher may make unsustained assertions so, too, may the charlatan, the blind leader, and the fanatic. In the second case, (b), these philosophers resort to the very method which they repudiate—the method of evidence—and in exploiting their examples of intuitive knowledge they undermine the "intuition" which they seek to establish or they end, as before, in dogmatizing. The so-called "intuitive" behavior of the mind readily resolves into elements which are accounted for through examination of mental development as neural phenomena self-geared, by evolution, into a working organism—albeit one liable to work badly.

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[1] J. M. Baldwin, *Dictionary of Philosophy.*

Notice should here be taken of a different use of the term feeling when it refers to many and varied bodily states or changes of state, mechanical or chemical in their nature. If, for instance, one falls out of a tree and breaks his arm he has a feeling quite different from the usual physiological arm-feeling; it is one of pain—a broken bone in an arm is abnormal and the nerves concerned promptly report this bodily injury at neural headquarters. The person's friend, seeing or hearing of the injury, also has a feeling—one of the type to which emotions belong; he feels pity, he is sorry that the accident happened. The arm is broken, something must be done about it, is the reaction on the part both of the sufferer and his friend. But "something must be done" is not dictated by the feeling of physical pain or the friend's feeling of pity—much less is the instruction what to do. A surgeon's knowledge is now in order.

With intelligence and consciousness as accounted for in this chapter, we have implicitly a definition of knowledge. Explicitly stated: *Knowledge is recognition of sense impresses and perceptions as primary material, together with all elaborations of this material in the form of concepts, judgments, and inferences. As such, knowledge must be objective, verifiable, and communicable.*

The remainder of this book relates to this definition.

CHAPTER III

A Man and a Dog

"There will be an eclipse of the sun on the 10th of next September, beginning for us here in New York City at 43 minutes past 3 and ending at 28 minutes past 5 P.M., E.S.T. Only partial here but total in San Diego, California." The teacher made this announcement to a high school class in geometry, March 12, 1923. A respectful hand was raised and a pupil asked "How do you know?"

"The whole of this State was once covered with a vast, thick sheet of ice." "I'd like to ask the lecturer a question," came from the rear of the room, "how does he know?"

"Yes, after I had dug and dug in other spots, that fellow took a hazel twig and located the water right here; he knew where to dig." How did he know?" inquired the stranger.

"A bad spell o' weather, neighbor; but the moon changes to-night; you can plan for fair days, now." A bystander wondered, "How does he know?"

"The great modern advances in civilization have been made under capitalism," declared one speaker in the debate—implying in what he further said that they not only could not have been made under any other economic system, but also that capitalism was the cause of social progress and achievement. "How does he know?" demanded one hearer in an undertone.

In chapter II knowledge has been defined, and in arriving at that definition the essential features marking the acquirement of knowledge have been suggested. It is necessary to examine more closely the nature of the basis underlying any sound answer to the question, "How do you know?" To put the matter in its simplest and most elementary form we may begin by supposing the following ordinary, and hence typical, situation:

A man and a dog are coming along the road. The man is just a plain average person and the dog is of no particular breed. They have been across the hills to salt some cattle and are returning by way of the country store and post-office at the crossroads. The man walks straight ahead, while the dog makes occasional detours into the bushes, exploring for creatures that are game to him: a rabbit, perhaps a snake, or even a grasshopper; but most of the time he trots at his master's heels. They are both hungry, but it is near sunset; they will soon eat and then sleep. The man, said to be "civilized," will have several kinds of food which he will eat from dishes made in another country; he will sleep in a bed spread with sheets and blankets. The dog will gnaw his meaty bone at the kitchen door and later curl up on the floor in the back entry.

During the day these two creatures, by "using" their eyes and ears, have made connection with their surroundings. The dog has also used his nose and both have tasted food with relish. Their eyes, ears, noses, tongues, fingers, and paws, were of the nature of gateways through which sense impresses

affording knowledge came, or could have come, to them from things outside themselves. "The light of knowledge can enter by the ear-door as well as the eye-window."[1] This knowledge was, strictly speaking, knowledge of the *properties* of the thing, though for convenience we speak of knowledge of the stone, or the tree, or the cloud, rather than knowledge of the properties of these objects.

As might be inferred from the discussion of consciousness in chapter II, the measure of consciousness depends largely on "(1) the extent and variety of past sense-impresses, and (2) the degree to which the brain can permanently preserve these impresses; or what might be termed the complexity and plasticity of the brain."[2] A large part of a baby's business is to build up consciousness by acquiring sense impresses; or, more accurately speaking, consciousness builds itself up to a point where the baby begins to "take notice." This taking notice is the first of the three most important events in the baby's life; the second occurs when he recognizes. As compared with the young of many other animals—colts, calves, chickens, and so on—the human young is prematurely born. It has the advantage of kittens and puppies in having its eyes open at birth, but in most other respects it is far more feeble and helpless. The baby does not "learn to walk," he walks—"stands up on his hind legs" and goes—when he is sufficiently mature.

When a creature—the man animal or other ani-

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[1] F. L. Oswald, *Summerland Sketches,* p. 279.
[2] Karl Pearson, *The Grammar of Science,* p. 53.

mal—is so far conscious that he is aware of the likeness, or unlikeness, of a present sense impress with another present one, or with a past one which is "remembered," he begins to learn. This awareness of likeness or unlikeness—the comparison of sense impresses—is *perception;* it is a judgment which amounts to knowledge of some property or properties of the object which is the source of the sense impress.

That dog ran between the fence and some briery blackberry stalks. After getting through he did not come back the same way; he had knowledge that led him to go around. The briers scratched his side; he perceived to a certain extent the difference between blackberry stalks and, say, elder stalks. The man had an eye impress of color from above; and he perceived that masses of whitish-gray clouds obscured some of the blue area. Memories of clouds and of rains were associated, so that the perception of clouds suggested rain; he "wondered" whether it would rain soon. Wonder may be incidental and transient—appearing and then vanishing—in which case it has no value as a prelude to knowledge; or it may be a worthy curiosity, a puzzled state, often preparatory to steps toward replacing it with fact. This man's wonder was usually of the former kind.

The dog saw his master climb the fence. He had, we may suppose, no names—at least no expressible names—for the properties of the rails: hard, gray, rough,—but he perceived the rails; he also perceived that an upper rail had been placed high on top so that he could not bound over as he had been wont

to do; he then whimpered and dashed along until he found a new place conveniently low.

Besides perceiving the rails the man grouped his perceptions—these like perceptions which many objects afforded. Through sight and touch he was aware that these things were about equally long, thick, hard, and of the same color. They had a common purpose: to form a barrier; if put into the fire they would burn; if left in place long enough they would decay. Out of these similar perceptions emerged the *concept* rail. He meant no particular rail of this particular fence, or any particular rail of the entire countryside, but just rail. Was the dog likewise able to compare and group his rail perceptions, discovering their similarity, and so acquiring the concept rail? Did John Muir's Stickeen, one of the most remarkable of dogs, have the concept *crevasse;* or was it merely one crevasse after another, this and that crevasse—especially that dreadful last one—that he knew?

As regards intelligence and consciousness in dogs there can be no question. The brain of the dog and his behavior bear witness each for the other. What we should like to know is, how far beyond perception, in the direction of those cerebral operations properly called thinking, the genus *Canis* may have gone. The understanding of Rab, the devotion of Greyfriars Bobby, the high daring and fellowship of Stickeen, are supplemented by the stories that everyone is ready to tell of "a dog he knew." Yet in no way, by speech or act, has the dog told us whether he can form concepts.

The term *experience,* sometimes used to denote a single sense impress, is more frequently employed to mark a group of connected sense impresses. Thus the dog had the experience of going among the blackberry stalks trailing a rabbit; the man had the experience of watching his cattle as they pushed for place where the little heap of salt lay, and of seeing them lick it up with apparent relish. *Thinking,* sometimes defined as "a flow of ideas," may be better defined as a comparison of experiences. The cattle's eagerness for salt brought about a comparison of that observed eagerness with his own desire for salt on his meat. This was a start in thinking; a next step might have been a recognition of some other likeness in desires or behavior between man and animal: desire for company, for shade on a hot day, and so on, with these comparisons followed by other connected ideas: why does a human being like shade and cool water. But the man did not have the thinking habit; quite likely he dropped the thought of the salt and began to wonder whether that greedy black steer was not in good condition to sell. Not life but how to get a dollar determined the field of this man's disjointed thinking; for, as remarked before, he was an average man.

"*Reflection* is that form of thought in which all the experiences are revived or remembered ones; and most of the serious thinking which is done by mankind is of this character."[1] But reflection must be carefully distinguished from reverie. The latter

[1] L. F. Ward, *Dynamic Sociology,* Vol. I, p. 380.

is one of the lowest forms of cerebral activity in consciousness; it may, indeed, deal with revived or remembered experiences but it does this so aimlessly and at random that no new idea marks the outcome. True reflection requires effort; as a habit it is hard to form because it involves an expenditure of brain energy and makes one tired. But reverie—fatal consumer of time—calls for no effort and exhibits no fruits.

Observation is a species of experience marked by being voluntary and purposeful. A field geologist sets out with the intention of securing many sense impresses—chiefly through the eye—from a certain range or class of objects. He carefully notices rock outcrops, dips, and strikes; if he is in a region of sedimentary rocks he takes pains to see whether the rock is sandstone or limestone or some other kind. In case the rock is not clearly limestone in visual appearance and yet is suspected of being such he breathes upon a fresh surface and then smells of it —a characteristic sense impress by way of the nose being obtained if it is limestone. In order that other obtrusive and disturbing sense impresses may not hinder the work in hand the geologist attends strictly to the objects regarding which he is seeking knowledge. A botanist in the same territory "gives his attention" to an entirely different series of objects. If he is interested in limestone or sandstone as such it is only an incidental interest—because of its relation to the objects which he is observing, certain forms of plant life. For instance, if he is on sandstone he will not search for the walking-leaf (*Camp-*

tosorus rhizophyllus) unless he hopes to find exceptions to that plant's partiality for calcareous rocks. If a zoölogist goes over the same ground he observes still a third class of objects, sources of sense impresses; his eyes are trained on that which quite escapes the observation of the geologist and botanist. In contrast with these field students the ordinary traveler, with no especial plan except to get through the country, has a miscellaneous unsought set of impressions. He believes he saw some rocks somewhere along back, saw some woods, and heard some birds; but he observed nothing; his experiences are a vague group of desultory sense impresses quite without value. "It was a pleasant day and a rather pretty country, but he got tired," is the substance of his report.

As regards the nature of *attention,* certain sense impresses—either just being received through sense organs or arising from among other stored impresses—are, for the time being, more prominent in consciousness than all the others. If we ask how this comes to be the case, reflection on the question gives the answer: Ideas, desires, purposes, growing out of the past life operate causally to secure this prominence. Thus the geologist has reasons for attending to what concerns him as a geologist.

Supposing the problem be that of acquiring power in thinking, it is evident that the desire and purpose to acquire this power must itself be cultivated until it is a match—and more—for antagonistic desires. If education is ever placed on a scientific basis it seems imperative that the student, young or

old, shall not merely be told to "pay attention"; but he shall be shown what is happening when his "mind wanders," or, positively stated, what "paying attention" means. Definite laboratory work, in which the student's own intelligence is his material for study—parallel with the sense impresses which call the intelligence into action—will become a fundamental factor in that as yet unattempted educational training. The source of these sense impresses may be a triangle or an earthworm, the Harvest Moon, or a strip of zinc in sulphuric acid; he who can give unwavering attention to such matters as these has crossed the first ditch and captured a ravelin of the fortress of knowledge.

Experiment differs from observation in that the objects dealt with are under control and subjected to instrumental, or other purposely arranged, treatment. Thus the physicist needs a laboratory fitted up with apparatus; he must weigh and measure and, so far as possible, he must finally express his knowledge in mathematical formulas which are brief general statements summing up certain facts regarding the behavior of unorganized matter, electricity, and ether. The vast mass of knowledge known as physiology is almost wholly due to the united labors of investigators in the laboratory equipped with material and with every appliance that inventive genius can devise for the study of organized matter in body form.

As people advance in years they tend to drop into a reminiscent state, that is, to "live in the past." The lifelong accumulation of sense impresses, to-

gether with derivative products and associated emotions, is so great that consciousness is occupied with them; the memory is over-stored and unfortunately much of the stock is rubbish picked up along the way. One remembered element from this store calls up so many others that new sense impresses meet scant hospitality. The old woman has a kindly but counterfeited interest in her grandchild's pansy bed —she is remembering the violets of long ago and permitting them to "occupy her mind." While common this reminiscent state is not unavoidable. "Keeping young" is possible through a resolution to show no favors to bygone experiences, obliging them to share with the world of the present. Age has this advantage, however: storing away new sense impresses may be more difficult in age than in youth, but reflection, as above defined, should be less difficult.

It is no more than natural that one should be skeptical as regards the capacity of any portion of the cerebral cortex—only a few cubic inches at most—for the recording of the multitude of memories of a lifetime. This apparent difficulty of cerebral storage may be lessened at least by considering another physiological matter quite as remarkable and unquestionable: "There is perhaps no phenomenon which is so impressive as the development from a minute speck of protoplasm, the fertilized egg, of an individual partaking of the minutest characteristics of both parents."[1]

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[1] E. H. Starling, *Principles of Human Physiology,* p. 1264.

Prisoners deprived of liberty find this hardship greatly increased by the lack of variety in surrounding objects, and the consquent repetition of the same sense impresses without break. The cerebral physiological effect is one of pain. Kropotkin thus describes his first experiences in the Fortress of Peter and Paul:

"Absolute silence reigned all around. I dragged my stool to the window and looked upon the little bit of sky that I could see; I tried to catch any sound from the Nevá or from the town on the opposite side of the river, but I could not. This dead silence began to oppress me, and I tried to sing, softly at first, and louder and louder afterwards.

"Have I then to say farewell to love forever?" I caught myself singing from my favorite opera, Glínka's Ruslán and Ludmíla."

"Sir, do not sing, please," a bass voice said through the food-window in my door.

"I *will* sing."

"You must not."

"I will sing nevertheless."

Then came the governor, who tried to persuade me that I must not sing, as it would have to be reported to the commander of the fortress and so on.

"But my throat will become blocked and my lungs useless if I do not speak and cannot sing," I tried to argue.

"Better try to sing in a lower tone, more or less to yourself," said the old governor in a supplicatory manner."[1]

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[1] P. Kropotkin, *Memoirs of a Revolutionist*, p. 345.

"The need of new impressions is so great in prison that, when I walked in our narrow yard, I always kept my eyes fixed upon the high gilt spire of the fortress cathedral. This was the only thing in my surroundings which changed its aspect, and I liked to see it glittering like pure gold when the sun shone from a clear sky, or assuming a fairy aspect when a light bluish haze lay on the town, or becoming steel gray when dark clouds obscured the sky."[1]

Returning to the man and the dog, if we compare their mental behavior the higher per cent. of mental effort is distinctly on the side of the dog. He acts as if he were using all his sense organs, and also all the mind he has; whereas the man has used chiefly one sense and very little of his mind and that in a most imperfect way. Most of his mental action has been of a habitual groove-running sort, a repetition of many yesterdays: A dull consideration of the growth of his cattle; the probable yield of his potatoes; the likelihood of rain. But within easy reach of his senses were objects, motion, and life: The horizon-blue where earth and sky met; the dotted ferns in the fence-corners; the plaintive notes of the wood-pewee; the odor of the pennyroyal bruised by his feet in crossing the pasture. The man's brain was so far from free to receive these signals from the external world that the sense gateways might almost as well have been closed. And since he did not receive, of course he did not perceive. He was preoccupied, and this preoccupancy was due to care

[1] *Opus cit.*, p. 353.

and to habit. Concern that his cattle and crops should thrive ruled in that part of his mind which might otherwise have been engaged in fresh perceptions, new thoughts, and the acquiring of additional knowledge. This concern was a social inheritance from many ancestors who had needed to care about such matters as the catch of fish and a supply of fire-wood. As for knowledge elaborated from sense impresses he depended on what he had learned years before; most of it was of a traditional nature—a social inheritance, like his anxieties. He did things as he had seen his father do them. In some cases he had verified in experience these ancestral teachings. Thus he knew that chestnut posts last longer than posts of oak or pine; but he also held that potatoes must be planted in "the old of the moon."

The dog had sense impresses—many more, probably, than his master had. His senses of sight and hearing were not only unimpaired, but they worked up to their full capacity; he saw and heard all day long. His impresses through the organ of smell were more acute and more varied than his master's; the man did not even try to smell things. The dog had no permanent worries, and hence no bondage to them; he knew neither his forebears nor any instruction of theirs—though he buried the bone in the garden after he had eaten all he wanted, and he turned round and round a few times before lying down to sleep in the entry.

When they came to the post-office the man was given a paper; he went that way in order to get it.

After his evening meal he looked at it awhile before going to bed. Besides the paper he had some books in his house; but he scarcely cared to read them—even those that were of any value. He had much rather spend his Saturday afternoons at the ball game on the distant village grounds. The dog possessed no printed page, even as he wore no clothes. For him there were only the few dogs of his neighborhood, and no more of a world than the fields and woods of his master's farm, with the road along which they came and the store—the pleasant smelly store—at the cross-roads. Yet, on the whole, as already remarked, the dog made a relatively better mental showing than did the man who, in addition to being ignorant, was credulous and superstitious; which is to say that he believed without asking for evidence; he could give no satisfactory account of how he knew what he thought he knew—at least as regarded most of it.

Lest this man be held in contempt it may be again stated that he is an average person, a composite of the city resident equally with the country dweller, of the man who left school at fourteen and the man who fancies himself educated because he has "gone through college." His superstitions—of which those relating the moon are far from being the worst—are average superstitions and his ignorance the prevailing ignorance. It is because he is representative that his mental conduct is a matter of great moment.

In this chapter the following terms have been informally but carefully defined and illustrated: per-

ception; concept; experience; thinking; reflection; attention; observation; experiment. Perhaps the importance of definition has incidentally been suggested. The next chapter will be occupied with this subject: Words and their meaning.

CHAPTER IV

Words and Their Meaning

In the long course of evolution from an ancestral creature with merely a sensitive body-covering to give it reaction contact with an outside world of stimuli one genus finally emerges equipped not only with sense organs, a backbone, a nearly upright position, and an opposable thumb, but also with such modifications of throat and mouth that articulate sounds became possible. We must not think of the variations which resulted in these immensely important features as limited to a few centuries, or even a few thousand years; the process was undoubtedly a gradual one, extending over many thousands of years.

There never was a time when it could have been said: These creatures are animals but their immediate offspring are human beings. Mother-wit along with mother-instinct—enough to safeguard and rear the helpless young—existed continuously; call it instinct or wit, this mother quality is far older than the human race. But there was no mother-lore transmitted as such. By degrees folk-ways appeared—ways to secure food and avoid harm—that might be imitated by the young but not otherwise passed on as instruction. B imitated A; the imitating act of B was preceded by an unconsciously suggestive act on the part of A. To be available, B needed a certain degree of brain development; that

is, a certain degree of ability to take notice. All such acts as climbing, bending saplings, cracking nuts, were of this kind, and doubtless took place long prior to anything that could be called speech. It was the language of instructive action and as such it supplemented instinctive and impulsive action. Intelligent and sagacious animals, whether wild or domesticated, avail themselves of it in varying degrees.

Circumstances and improving brain in time induced sound-making, a greater variety of sounds than any of primitive man's purely animal kin could make. It must be regarded as one of the significant achievements of this creature, coming to be human, when things were marked by sounds; and one of his greatest advances when, without deliberate intention, the same sound was used again and again for the same thing until the advantage fixed the habit. Possibly this began through hearing the oft-repeated notes and cries of birds, the growls and snarls of wild beasts. Thus if our common wild goose was the contemporary of primitive man its "honk" might well have suggested a vocal mark for the bird itself rather than, as now, merely the name of the bird's note or cry. This is assuming that the words, honk and goose, are of different origin; but goose, under various forms, appears in so many Eurasian languages—sometimes with an initial *g* and again with *h,* as in the Sanskrit *hansa* (whence the Hindustani *hans*)—that the idea arises that this stem *gan,* or *han,* reveals to us a bird's name modeled long ago after the bird's cry. It is only the ornithologist who

goes far out of his way, for reasons of his own, to call our common wild goose *Branta canadensis.* In addition to the possibilities in the goose's name, it is certain that we do use their notes in the case of various other birds; thus in English we have: chickadee, phoebe, chippy, killdee, pewee, towhee, bobwhite, whippoorwill, and hoot-owl.

For primitive man, then, we may well suppose that the growl of the cave-bear marked and meant the bear; to imitate him was to name him. The snarl of the sabre-toothed tiger likewise meant the tiger. But many objects in the life of this man without a language—objects which his descendants now name tree, cave, meat, egg, nut—made no sound; hence, arbitrary sounds had to be attached to them. At the same time, we may suppose, actions and conditions—to eat, to run, to sleep, and so on—were given vocal marks. The store of words must have increased very slowly, because a small stock would meet all needs, and need is the motive clue to most of early man's activities; he was pushed to the devising of speech by the exigencies and necessities of life's experiences. The push of need would have come to naught, however, had there not been sufficient brain development, together with changes in throat and mouth, to devise a response to the need. It can hardly be wondered at that a vocabulary was extremely slow in forming. We today have few words for tastes and smells; why do we not coin a word for the fragrance of the rose, for instance, and do it without drawing on some other language than our own for material? On the other hand and

from another point of view, it is amazing when one considers what the human race has achieved—even with many thousands of years to do it in—the languages of Homer and Shakespeare.

Animals are far from being without social traits; they are, as a rule, gregarious and they show a disposition to mutual aid as well as to mere sociability. With the power of speech and with the elements of language an accomplished fact, companionship among human animals rose to higher levels and larger possibilities. The conveying of simple knowledge otherwise than through action became feasible. The primitive brain, as well as the hand, had to be used if our very great-grandfathers were to find better ways to catch fish, to protect the cave, and to express themselves to one another. The brain, thus improved through effort and use, became in turn a cause of other improvement—an increased ability to communicate as well as fitness to live. At length tradition emerged and history as a folk-tale was born.

Starling writes: "In speech we have a symbolism which acts as an economy of thought or of cerebral activities. An object, such as a table, with its associated properties of color, consistence, spatial extension, and resistance, with the connoted acts associated with its use, can now be evoked as a word, involving comparatively simple auditory and motor processes, which itself may be employed as a unit of thought and brought into connection with other words, each of which in the same way is the symbol for a whole series of sensory and motor processes.

The training of the cultivated man consists in a constant extension of the range of this symbolism, and the acquisition of words including wider and wider groups of neural processes, so that finally we arrive at those short verbal collections which, as the so-called *natural laws,* summarize the experience not only of the individual but such as is common to the whole race of mankind."[1]

Expression of the verb *to be* was an especial achievement. To run, to climb, to eat, and so on, while more simple ideas, are less elementary and far less generic than to be. This latter is so fundamental that it is, of course, merely masked by such verbs as to run, since to run is to be running. The bear perhaps had a name, and more than that the pit a name, a very long time before the digger of the pit attempted to express, Bear is in pit. But it made a difference whether the fact was: Bear is in pit, bear was in pit, or bear will be in pit. The primitive hunter and trapper learned that he must somehow convey the distinction; by prefix, or suffix, or fusion, or an additional individual vocal mark, he must express existence with time involved—though he was wholly unable to recognize his problem in this way. We ourselves cannot escape this verb, *to be;* for the most elaborate sentences, whether in categorical or conditional form, either contain explicitly, or can be shown to contain implicitly, the word of being.

We are thrown back on conjecture again in trying

[1] E. H. Starling. *Principles of Human Physiology,* p. 454.

to trace the mental growth of man up to the point of forming concepts; when he was able to disregard individual objects and to treat comparatively a series or range of objects, noting that they shared certain qualities or properties. It was a mentally dramatic period in that lost pre-history when persons with the best minds really struggled through to the concept; when, for instance, one could say *tree* without meaning the tree he slept under last night, or the tree that was blown over. Undoubtedly that power of abstraction came relatively late. Further, such general terms as tree, skin, stone, (the original equivalents of these words), would precede others acquired with even greater effort—words which English-speaking people mark, in many cases, by the ending, *-ness*. Let anyone try to think of *sweetness,* for instance, and keep sugar, candy, honey, syrup, out of his thoughts; or of *wetness* apart from water or other liquid, and he may sympathize with man's first efforts to master a few concepts.

From what has been said it appears that name words fall into two groups, since a name either belongs to one thing or to a number of things which have one or more characteristics in common. Names of the first class are known as *singular* names (terms), and those of the second class as *general* names. For example, the Kew Gardens, the Matterhorn, the Great Wall of China, the Fram, John Brown, are singular names; while garden, mountain, wall, ship, man, are general.

Again, general names (terms) fall into two groups: *concrete* and *abstract*—abstract terms re-

ferring to qualities or attributes, rather than to the thing which possesses the qualities or attributes. Thus roundness, heaviness, and the like, are abstract terms while ball, metal, and so on, are concrete. It is not easy, however, in all cases to draw a sharp line between concrete and abstract terms; because terms range from being less concrete to somewhat abstract and thence to most abstract. For example: iron, metal, weight, heaviness. Just as singular terms probably preceded general ones in order of origin, concrete terms preceded abstract ones.

"The first step toward clear thinking is to know what we mean by the chief terms used."[1] It may be added that there can be no clear understanding of one person by another, when thought is expressed, without adequate definition. Defining is stating what we mean by a term. Mill says: "The simplest and most correct notion of definition is a proposition declaratory of the meaning of a word; namely, either the meaning which it bears in common acceptation, or that which the speaker or writer, for the particular purposes of his discourse, intends to annex to it."[2]

The following requirements and limitations, formally stated, will serve both to emphasize the importance of definition and to aid in using words as demanded by "clear thinking" and clear understanding:

1. Description is not definition. Singular terms belong to objects which can only be described; while

[1] Edith Simcox, *Natural Law,* p. 6.
[2] John Stuart Mill, *Logic,* Vol. I, p. 150.

all general terms admit of definition. For example, we find a description of the *Fram* in Nansen's *Farthest North,* chap. II; a definition of the term ship is implied.

2. A substituted term from another language, or the translation of the term, does not serve as a definition. Thus the term *triangle* is not defined by saying that it is a three-cornered figure, because *tri* means three. Democracy is not defined by translating it, "a government of the people."

3. Synonyms do not define. To use one, while it may have advantages, is merely to shift the burden to another term which needs defining quite as much as the first.

4. Cases may occur in which two associated words require to be defined together. For instance, what is meant by *opposable thumb?* It is scarcely enough to define opposable by itself, and thumb by itself, and then take the two definitions as giving clearly the meaning of what is practically one term though two words. As other important examples we may note: *cerebral cortex, human nature, law of nature, associative memory.* Each one of these phrases requires definition as one term.

5. A definition may be rendered valueless by the presence of a term which is vague or misleading and hence itself in need of careful definition. Thus if *image* occurs in a definition of *idea,* image must be immediately defined in case this had not been done before the definition of idea was offered (p. 29).

6. The requirement of clearness of definition does

not permit the use therein of any term that is ambiguous, or figurative, or merely negative. Ambiguous and figurative terms are, from their nature, hostile to that clearness which definition demands. As regards negatives instances readily suggest themselves which show that a term cannot be defined by any statement of what it is not. For example, "Teaching is not telling." This is quite true but it is not a definition of teaching.

7. The term to be defined must not appear in the definition—either the word itself as given, or in the form of some other "part of speech," or disguised in a word from some other language. For example, the word *canine* may not appear in a definition of the term dog. It has to be added that this rule is frequently broken by "good authority;" thus the Century Dictionary informs us that a *communist* is "one who advocates and practises the doctrines of communism." Undoubtedly—at least as far as advocating goes—but what is communism?

8. Finally, a definition should be as brief as possible, provided that completeness is not sacrificed. For example, Bertrand Russell has defined *socialism* as "the advocacy of communal ownership of land and capital."[1] These nine words form what is probably the briefest definition ever offered of this somewhat difficult term, yet it is clear and adequate.

As indicated by Mill, all discourse, to be clear and worthy of attention, must adhere throughout to one meaning of a term. For instance, the important

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[1] Bertrand Russell, *Proposed Roads to Freedom,* p. 1.

term *phenomenon,* wherever used in this book, denotes any source, or associated sources, of stimuli which may affect one or more of the sense organs. In this meaning a bluebird singing in an apple-tree is a phenomenon.

Further, if a writer or speaker intends to employ a term in some unusual sense his intention should be stated at the outset or clearly indicated in the context. Mill's definition of *logic* is not the usual one; he is careful to tell his readers how he intends to use the word. Thorstein Veblen employs the term *idle curiosity* in a novel and vigorous way, but he leaves us in no doubt as to what he means by it.[1]

Many words of every-day life are, happily, free from uncertainty of meaning, though it may be far from easy to define some of them. Thus dog, road, tree, food, coat, north, hill, star, are terms that we use with practical correctness; but take the first on the list; how shall we define dog? We must do it so as to exclude cat, horse, human being, butterfly, oyster, indeed, everything which has some property or characteristic which marks it as not being a dog; and, as remarked under rule 6, this can be done only by making affirmations. Shall we exclude wolves? We are now not quite so sure. Perhaps a dog is a kind of wolf; or, conversely, perhaps a wolf is a kind of dog. Further, our definition must not refer to any particular color or size, or to any feature belonging to collies or hounds or any other variety of dog as such. If we ask help from a zoölogist he

[1] Thorstein Veblen, *The Higher Learning in America,* p. 176.

makes statements about teeth, feet, skull, including what characterizes dogs alone, thus ruling out other four-footed mammals.

The reader will find it a most profitable exercise to write definitions—not from memory but from his understanding of the terms chosen—checking them by some good dictionary but bearing in mind that "dictionary definitions" often leave much to be desired. For instance, let him try defining *south*—adding to his own, definitions which others are willing to contribute. By that time he will be keen to consult a dictionary. The Century Dictionary uses the term *meridian* in the best definition which it has to offer; then, of course, meridian must be defined before the definition of south is satisfactory. In reaching a clear, complete, and accurate definition of the common term *south,* the student will find that he has necessarily picked up more than he set out to learn of geometry and astronomy.

A second class of words, belonging to the exact, or near-exact, sciences—such words as alkali, ion, momentum, parallax, parsec, syncline—are understood in exactly the same sense by persons who have occasion to use them. Others may not know the meaning of the terms, but that is quite different from saying that they are ambiguous, or even difficult of definition.

On the other hand, words of a third class—in more general use than scientific ones—are a source of confusion and worse, because people are far from agreed as to their proper significance. Who can tell just what is meant, or ought to be meant, by such

terms as civilization, culture, democracy, education, justice, liberty, loyalty, patriotism, religion, treason? Dictionaries quite fail to standardize their meaning; but dictionaries can hardly be blamed where so much disagreement exists as to these "great trite words which come so readily to the tongue." The treatment of the term *civilization* serves for illustration. Ward says: "Civilization may be defined as the artificial adjustment of natural objects in such a manner that the natural forces will thereby produce results advantageous to man."[1] Sir Henry Maine writes: "Nobody is at liberty to attack several (private) property and to say at the same time that he values civilization. The history of the two cannot be disentangled."[2] Tylor begins his *Primitive Culture* with the proposition: "Culture, or civilization, taken in its widest ethnographic sense, is that complex whole which includes knowledge, belief, art, morals, law, custom, or any other capabilities and habits acquired by man as a member of society."[3] But Matthew Arnold would not admit the identity made by Tylor, for he writes: "Culture, the acquainting ourselves with the best that has been known and said in the world, and thus with the history of the human spirit."[4]

With such widely divergent views as the above who shall determine and enforce any stated meaning for the term in question. However, as it stands—unlimited and unqualified by any adjective—it seems

[1] L. F. Ward, *Dynamic Sociology,* Vol. II, p. 205.
[2] Henry Maine, *The Rede Lecture for* 1875.
[3] E. B. Tylor, *Primitive Culture,* p. 1.
[4] Matthew Arnold, *Literature and Dogma,* Preface, p. xi.

necessary to say that no adequate definition can be given without reckoning with all the known civilizations of the human race. What have they all had in common? Such a thoroughgoing comparison probably underlies the definition given by Ward. As a similar bit of work the reader will find it worth while to compare the principal known religions from earliest historical times to the present. However dissimilar they nevertheless have one dominant feature in common. To disregard it in definition merely creates confused thinking.

Another of the "great trite words," perhaps the most important in the list given above, is *justice*. Ulpian, Roman jurist and associate editor of Justinian's *Digest,* says: "Justice is a constant, unfailing disposition to give every one his legal due (*jus*). The principles of law are these: Live uprightly, injure no man, give every man his due." It should be noted in passing that Ulpian uses the word *jus,* the basis of the English word justice, not *lex* (statute law) as one might suppose from Monro's translation. But what is one's "legal due"? Does it call for equality without distinction among classes or individuals? Evidently not, in the Roman jurist's estimation, for slavery was an established and unchallenged feature of Roman society. Further, what is it to "live uprightly"? What one person —even in Ulpian's time—would regard as living uprightly another might declare to be not living uprightly at all. The great affirmation of the Magna Charta reads: "We will sell to no man, to no man will we deny or delay, justice or right" (*justiciam*

aut rectum). These are stirring words, but before one gets much stirred he will do well to inquire what was meant by the term "man" when barons of 1215 wrote it into their Great Charter. A historical examination of the term justice—that is, of the popular meaning attaching to the term in any given period—discloses a long series of re-definitions. What the majority of the people of one age have accepted as just has been repudiated in another age as wholly unjust. In fact, the variation in understanding of this one term alone serves as a fairly good record of the ethical development of the people using it. If any ultimate definition is ever reached, it will certainly be freed from the vagueness of Ulpian's summary and the indeterminate quality of state documents originating in later centuries.

Not only nouns as general terms need definition; the same is true of adjectives and adverbs, and often of associated nouns or nouns and other parts of speech closely combined (4. p. 63). For example, Darwin expresses his conviction: "A man who dares to waste an hour of time has not discovered the value of life." But people are not agreed as to what constitutes a "waste of time." We guess what Darwin meant by it when his son Francis writes: "He never wasted a few spare minutes from thinking it was not worth while to set to work." Yet this great worker did not work all the time; he walked in his garden, rode his horse, and listened to reading. He took recreation and rest, but he never "loafed" or dawdled; and the needed recreation was not counted as waste.

A definition or meaning assigned to one term often implies a certain definition of another. Thus if it be said that geometry is not a science, such a definition of science is implied as shall exclude geometry (p. 72). Or if one makes the statement that "the man of education is moved largely by ideals," he is to try to save it by defining "education" in such a way as to serve the purpose. An eminent Chinese, Wu Ting Fang, once expressed the view that "a highly civilized man can sympathize with the men of every country."[1] Accepting this, the term, "highly civilized," must be defined accordingly. It may be observed in passing that Wu Ting Fang's statement suggests an emotional quality in civilization not provided for in any of the definitions given on an earlier page. To illustrate further, Malthus declares: "The checks which repress the superior power of population, and keep its effects on a level with the means of subsistence, are all resolvable into moral restraint, vice and misery."[2] This assertion, while not itself a definition, nevertheless turns for its truth on definitions of three terms in it. In order to save the statement, "moral restraint," "misery," and "vice" must carry some peculiar and unwonted meanings. Again, in Amendment VIII, Constitution of the United States, the phrase, "cruel and unusual punishments," occurs. When is a punishment "cruel" or "unusual"? One is also obliged to ask: Can the definition of terms of this nature be safely left to one man—a judge or a penitentiary warden

[1] Wu Ting Fang, "The Public," 1901.
[2] T. R. Malthus, *Population.*

—or even to nine men selected from one class in society?

Over and above the difficulties of definition, and assuming that definitions are agreed upon as meeting all essential requirements for the purposes of mutual understanding, it remains true that even quite ordinary general terms mean very different things to different persons. Consider, for example, the term *forest*. To the pioneer in the Northwest in the early part of the nineteenth century forest meant great numbers of trees serving as an obstacle to agriculture—something to be got speedily out of the way by ax-work and fire; to the lumberman it means so many feet of lumber which will yield certain net profits per foot in the market; to the forester it means a field for scientific management of trees as a crop; to the hunter it is the haunt of game; to the artist it is a background; to the physiographer it is a factor in the conservation of rainfall and in the prevention of erosion; to the naturalist it is a place of alluring attractions—the great trees themselves, so varied, and the life of beast and bird and wild flower sheltered there; in his enthusiasm Audubon exclaimed: "The beautiful, the darling forests of Ohio, Pennsylvania, and Kentucky!" Yet all these persons would agree on the definition of forest as given in the Century Dictionary: "A tract of land covered with trees; a wood, usually of considerable size."

Thus the full meaning which a word carries for any person depends upon the knowledge, the culture, the tastes, and even the occupation, of that per-

son. One gets on with his neighbor, using words in their simplest most ordinary sense; the words serve the purpose because both persons have a common understanding of them; but each holds in reserve much, perhaps most, that a given word signifies in his own mind. He could not—if he would—reveal its whole significance, because it is embedded in his life experience as recorded in the cerebral cortex. It would be impossible to convey to another the network of images which lies behind the word. What is properly marked by the term "acquirement of culture" consists largely not merely in gaining more words but in enriching the content of many words already a part of his personal vocabulary. Experience and reflection together convince us that this is a task for a lifetime. Culture cannot be bought in the market and put on like a new suit of clothes.

From the point of view just presented it is suggested that the reader examine himself as regards his grasp of such ordinary words as city, war, home, book, picture, travel, wealth, good time, and the like.

The following definitions are offered for study and criticism:

"Science is the discernment, discrimination, and classification of facts, and the discovery of their relations of sequence."[1]

"All labor consists in an artificial transformation of man's environment."[2]

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[1] J. W. Powell, *The Philosophic Bearings of Darwinism.*
[2] L. F. Ward, *Outlines of Sociology,* p. 256.

"Knowledge is made up of affirmations respecting the order of the world."[1]

"Knowledge is acquaintance with the environment."[2]

"Liberty is the natural power of doing what any one is disposed to do, save so far as a person is prevented by force or law."[3]

"That insidious and crafty animal, vulgarly called a statesman or politician, whose councils are directed by the momentary fluctuations of affairs."[4]

"Rationalism . . . to be significant to-day . . . should stand first and last for the habit and tendency to challenge the doctrines which claim 'religious' or sacrosanct authority—to seek by reflection a defensible theory of things rather than accept enrolment under traditional creeds which demand allegiance on supernaturalist grounds."[5]

From the following quotation select pairs of adjectives and define so as to bring out the difference in each case:

"Your friends are the dullest dogs I know. They are not beautiful: they are only decorated. They are not clean: they are only shaved and starched. They are not dignified: they are only fashionably dressed. They are not educated: they are only college passmen. They are not religious: they are only pewrenters. They are not moral: they are only conventional. They are not virtuous: they are only

[1] Alexander Bain, *Logic*, p. 21.
[2] L. F. Ward, *Dynamic Sociology*, Vol. II, p. 108.
[3] Florentinus, Justinian's *Digest*.
[4] Adam Smith, *Wealth of Nations*, Bk. IV, Chapter II, p. 469.
[5] J. M. Robertson, *Rationalism*, p. 8.

cowardly. They are not even vicious: they are only 'frail.' . . . They are not prosperous: they are only rich. They are not loyal: they are only servile; not dutiful, only sheepish; not public spirited, only patriotic; not courageous, only quarrelsome; not masterful, only domineering; not self-controlled, only obtuse; not self-respecting, only vain; not kind, only sentimental; not social, only gregarious; not considerate, only polite; not intelligent, only opinionated; not progressive, only factious; not imaginative, only superstitious; not just, only vindictive; not generous, only propitiatory; not disciplined, only cowed."—G. B. Shaw, *Man and Superman,* Act III.

NOTE.—The reader should study Appendix I before proceeding to the next chapter.

CHAPTER V

The Challenge of the Universal Affirmative

In Appendix I the structure of the syllogism and the rules for its working have been set forth. The premises were taken at their face value—no questions asked as to how we came by them. It is seen that the two premises, properly formed and related, not only permit the conclusion but compel it. That is, the conclusion is involved in the premises and nothing new is learned by stating it; all that is gained is that the involved proposition is brought clearly and conspicuously to our attention. It must therefore be realized that the syllogism is relatively unimportant. Knowledge is expressed in propositions, whether these propositions play the rôle of premises or not; and it is knowledge which is important. Further, unless the premises can be depended on as true, the conclusion has no value; it in turn cannot be depended on. This applies, of course, to all forms of the syllogism and to the dilemma.

But, "come to think about it," how do we get these propositions? For example, consider the universal affirmative in the syllogism on page 209; how do I know that "all pinks are fragrant"? I know that some are, because, as I call up my stored impresses of a flower having a certain structure and habit of growth, I find, coming up with these impresses of structure and habits, the sense impress

which carries the label "fragrant." A peculiar fragrance has characterized the pinks with which I have been acquainted. But you remind me that the pinks which I have seen and touched and smelled are a very small number comparatively; how do I know that *all* pinks are fragrant? Crowded hard I admit that I do not know that all of them are, but I do not recall having heard of a pink lacking fragrance. My position is unsatisfactory; it seems desirable to consult a standard work on systematic botany, and I look in Gray's *Manual* for the Pink Family and turn to the last genus, *Dianthus,* which bears the common names, pink, carnation. Not one of the four species is described by any odor word. But hold! The botany book deals with wild flowers alone. I have been carelessly thinking of the pink of the garden and greenhouse; probably I shall be nearer the truth if I say: All cultivated pinks are fragrant. And of course if I intend to use that statement as a premise the second premise, page 209, must be modified to, this is a cultivated pink, in order to conclude, this flower is fragrant. But what is to be done to make sure of this new universal affirmative? Evidently I must consult growers, professional and amateur, I must read florists' catalogs, landscape architects' books, and so on. To be absolutely sure I must know every variety of pink under cultivation. Anywhere along the line of this investigation—in case no scentless pink is listed—I may pause and say: So far as I know, cultivated pinks are fragrant. Adding, this is a cultivated pink, it may be con-

cluded; it is a safe guess that you will find this pink fragrant.

To illustrate further this process of approximating to an all-inclusive statement; while looking for the facts about the genus *Dianthus* it struck me as so peculiar that not one species of that genus was spoken of as fragrant that I decided to read the entire Pink Family through: were odor terms absent from all the other species? This reading resulted in the discovery that of the seventy species composing that family the flowers of one are described as "ill-scented," of another as "inodorous," and of two others as "fragrant." These facts suggest that either members of the Pink Family are curiously lacking in odor, or that botanists, for some reason, assign little value to the sense of smell as an avenue for sense impresses. What is the testimony of the Orchis Family? It would seem to be an important family for this systematic botany in its preliminary description makes the impressive statement: "A cosmopolitan family comprising about 7,000 species largely dependent on insects for pollination."[1] Examining it I find, out of the sixty-eight species growing in the region covered by this handbook, that two are spoken of as having "flowers fragrant." Turning to the great Rose Family with two hundred and fourteen species, no odor word is used in describing any flower, though the leaflets of the sweetbrier (*Rosa rubiginosa*) are described as "aromatic."

[1] Gray's *New Manual of Botany* (seventh edition). A Handbook of the Flowering Plants and Ferns of the Central and Northeastern United States and Adjacent Canada, p. 305.

The Lily Family offers a somewhat less meager record: one entire genus, *Allium* (onion, garlic), comprising eight species, is described as composed of "strong-scented and pungent herbs," while the flowers of three species of the genus *Smilax* are "carrion-scented"; also the flowers of *Trillium erectum* are "ill-scented." To offset these malodorous forms the genus *Muscari* has "small flowers, sometimes musk-scented," and the flowers of *M. racemosum*—one of the two species of this genus—are "deep blue, fragrant." Finally the genus *Convallaria,* with its one species *majalis* (lily of the valley), offers "sweet-scented nodding flowers." For one more case the Violet Family serves. *Viola odorata* receives distinguished mention as having "flowers very fragrant," but it is the English violet "introduced from Europe." It is certain, however, that several other species of the genus *Viola,* to which *odorata* belongs, are distinctly fragrant; for example, *Viola blanda.*

Entering this handbook with unquestionably fragrant species—rather than well-known families—in mind, several exceptional instances add themselves to the brief list given above. Thus the flowers of the squirrel corn (Fumitory Family) are described as "greenish white, tinged with rose, with the fragrance of hyacinths." Trailing arbutus (Heath Family) exhales a "rich spicy fragrance," and its relative, wintergreen or checkerberry, bears bright red berries which with the foliage "have the well-known spicy-aromatic flavor of the Sweet Birch," a taste term here creeping in. The Sweet Birch itself is described as having a bark very "sweet-

aromatic." Sassafras, also, is "a tree with spicy-aromatic bark." The partridge berry, a trailing evergreen herb, has "white fragrant flowers."

Further search through the eight hundred and forty-two pages of description in this handbook would no doubt increase the list of positive statements of knowledge acquired through the sense of smell. The outcome at this point is that one cannot say: Botanists disregard odor words in description; but, on the other hand, it seems safe to affirm: Botanists use odor words sparingly in description. Why do I make this assertion after examining five families? I can only answer that I selected what I believed to be important families, each one of which certainly contains fragrant species, and with the fifth the conviction was lodged in my mind that it would be useless to go on examining other families; it seemed wholly improbable that I should find odor words more plentiful elsewhere in the book. Another person might have been satisfied with four families, while yet another would not have stopped short of a dozen or more.

I am now sharply held up by that word, botanists. What botanists? I have looked into no systematic botany except Gray's *Manual,*—which has been revised, however, by two professors with the coöperation of various other botanists. All these students of plants must have been agreed to disregard odor words, as a rule. Obviously it is now necessary to consult other standard texts; if I find them agreeing on this point with the manual first resorted to, I can stand by that affirmative with much more confi-

dence; but even so it falls short of being a universal —there may be some botanists, whose writings escape my attention, who emphasize odor in description.

The preceding discussion, starting with a most simple and innocent-looking premise in an elementary syllogism, quite loses its air of triviality when the process described is recognized as broadly typical of learning through the use, directly or indirectly, of primary material afforded by sense impresses,—the thing learned struggling to amount to a universal affirmative.

To take another illustration, relatively unimportant yet excellent for the present purpose: Some person notices migrating wild geese flying in V-shaped formation; he notices their flight several times in different years and then affirms: Wild geese always fly in V-shaped formation with the leader at the advancing vertex. Then a second observer with a wider experience declares: Not so; I have occasionally seen them in linear formation—a single sinuous line. The first statement was unsustained by enough instances; more of them would have included the less frequent case, the linear formation. Yet how was the first observer to know that he had not seen migrating geese often enough? He did not know, but he took the risk of a universal—and adopted an untrue conclusion.

Animal behavior in general seems to offer a degree of variability which warns the cautious nature student to be chary of universals, whether affirmative or negative. "Usually," "as a rule," "so far

as I have observed," are safe modifiers until an accumulation of cases insists on an unqualified universal regarding some stated class of phenomena. But if "accumulation" seems both vague and excessive, and it be asked: How many instances must be observed? no rule can be given; the only answer is: It depends; it depends on the nature of the phenomena under observation.

Turning now to examples in which the resultant affirmatives express quantitative determinations; water when analyzed, let us say in a laboratory in England, proved to be composed, by chemical combination, of two gases, hydrogen and oxygen, in the proportion very nearly of two volumes of H to one of O. How many times, in how many places ,and at what different periods of time, must water be analyzed in order that we may confidently affirm the universal: Water is composed of the gases, hydrogen and oxygen, in the proportion very nearly of two volumes of H to one of O. Why do we not urge that this was doubtless true in the eighteenth century but is questionably so in the twentieth; or if true in England it may not be true in India or Alaska.

Again, the boiling-point of water is marked 212° on the Fahrenheit thermometer; this assumes normal atmospheric pressure; that is, sea-level pressure: 14.7 lbs. per square inch. Boiling (ebullition) is the bubbling up due to the lowest portions of the water becoming gas and escaping; this escape being possible when the temperature is such that the tension of the vapor is equal to the pressure of the atmosphere. Hence, with a diminishing of the at-

mospheric pressure—occasioned by ascending a mountain, for instance—ebullition will occur when the vapor tension is less; that is, when the temperature indicated is less than 212° F. How many times, and in how many places, must this phenomenon of boiling, and the variation on the graduated scale due to change in atmospheric pressure, be investigated in order to affirm: Water boils at 212° F., normal atmosphere pressure. In this case, as in the preceding one, the reply is properly made: A single experiment (instance) is sufficient—provided the accuracy of the chemist and the physicist can be depended on.

The passage from particular instances to a general proposition is known as *induction*. As has been shown in the examples in this chapter, no rule can be stated regarding the number of instances necessary for a safe induction. The number appears to depend on the nature of the phenomena dealt with; that is, it depends on the degree of likelihood that some binding causal feature characterizes the entire range of possible instances, including the unknown ones which the induction is to cover. Thus five families (instances) were carefully examined for odor words. When very few were found the induction was made without further examination. But there are one hundred and fifty-seven families described in the manual consulted. Five is so small a per cent. of the entire number that the inference would have been far from safe except for that "conviction" mentioned, p. 79, which really amounted to

a belief that some persisting reason existed for this negative action on the part of botanists.

The relief from any fancied need of repetition of chemical and physical experiments, in many laboratories, in various parts of the world, rests on the conviction that *Nature behaves uniformly*. And this conviction is itself an induction—the most important and far-reaching ever achieved by the human mind. Escape from the notion that Nature is capricious has been the indispensable preliminary to all acquirement of exact (quantitative) knowledge in those hardly distinguishable fields which we call physics and chemistry. If this fundamental induction is less impressively exhibited in the sciences which deal with life phenomena it is merely because such phenomena are made complex by the presence of baffling and mutually interfering factors. It is on account of these factors also—notably in all branches of sociology—that more than a few, sometimes many, instances must be observed before the inductive leap can safely be taken and a universal proposition justified. Even then, regard for truth often, if not usually, insists on the presence of some softening qualifying term which reduces the sweeping character of a universal affirmative (or negative).

The first study in induction offered in this chapter also serves to illustrate the way in which the question: How do you know this? may conduct, by suggestion, to another: How do you know that? The consideration of the universal fragrance of pinks yielded the field to another challenging prem-

ise: Botanists disregard odor words in description; and this finally weakened into: Botanists use odor words sparingly in description. But quite clearly the thoughtful student cannot stop with that; he will ask: What is the explanation of this fact—if it be a fact; why this lack of odor terms? The answer must apparently be sought either in the nature of plants themselves, or in the physiology of the sense organ concerned. Are the odors of wild flowers, leaves, barks, etc., so vague and elusive and even variable that they contribute little or nothing toward an account of themselves, or is the lack in the structure and functioning of the organ of smell? (As will be shown in a later chapter, we are now trying to frame a hypothesis.) Field botanists must answer the former question; as regards the latter, Starling makes the instructive and, for the present purposes, helpful statement that "in man the olfactory sense is but feebly developed, and the parts of the brain connected therewith are inconspicuous in comparison with those engaged in the reception of impressions from the other two main projicient sense organs, namely, sight and hearing."[1] This being true, one is led to surmise that if a dog were capable of examination, description, and classification, of wild plants odor words would not be used to such a limited extent as in the human being's botany.

[1] E. H. Starling, *Principles of Human Physiology,* p. 420.

CHAPTER VI

THE SENSES AND THEIR AIDS

Persons loath to admit that all knowledge is secured primarily through the senses sometimes point out what they call the limitations, imperfections, and false testimony, of the senses.

For instance, the ordinary eye cannot carry shades of color; two shades must actually be placed side by side as simultaneous sources of stimuli in order to pronounce them like or unlike. This fact, however, does not prove the inferiority of the eye as an avenue of sense impresses which precede and occasion perception. The inadequacy is in the brain where the cerebral records are not so distinct and persistent that a remembered shade may be successfully matched with a present one. Training is to be directed not to the eye but to the cerebral registration. Again, it is remarked that if one stands at some point between the rails of a long straight stretch of track the rails seem to converge. The tree in the distance looks much smaller than the one across the street, whereas in reality it may be much larger. As pointed out, p. 9, the eye has developed in accordance with the nature of light. The relation of rays of light proceeding from two points and entering the eye may be geometrically described; thus the size of the image—say of the tree—on the retina is determined by the angle formed within the eye by lines from the top of the tree and from the

foot, the angle being necessarily smaller the further away the tree is. Similarly, the distance between the rails is of course a constant, but the further away the rails between which the apparent distance is noted the smaller that distance must appear.

The apparent dinner-plate size of the moon is likewise due to its distance. If the moon, 238,862 miles from the earth, were only 10,000 miles distant —that is, only about one twenty-fourth as far away —it would seem to have an area when full nearly six hundred times as great as it seems at present, and would be an astonishing object in the sky—until we "got used to it." Even at its actual distance our absence of astonishment is due to familiarity; the observing human creature has developed under a single moon 2,100 miles in diameter and approximately 240,000 miles away.

A straight stick thrust obliquely into clear water has the appearance of being broken at the surface of the water; but again the organ of sight is not at fault; light behaves in a certain manner when passing from a medium of one density, say water, into a medium of different density, as air; and in consequence the stick must appear broken or bent; as another consequence, water is found to be deeper than it looks. The Indian, who knows nothing of the refraction of light, learns to drive his spear below the apparent place of the fish.

The senses should be given fair opportunity to bring in all their information on any specified phenomenon or group of phenomena. An immediate sense impress, in apparent disagreement with earlier

or later ones, will usually be found to be consistent with them, perhaps corrected by them. For example, anyone observing the half-moon with a ten- or twelve-inch refracting telescope sees a body that looks as if if it were made of some such material as plaster of Paris; it also looks as if it terminated in a wild ragged shore-line with white crags jutting out into empty space. Both of these impressions are corrected by means of a series of stored or subsequent ones. The observer judges from other visual impresses that the lunar surface is not white and gypsum-like; he also finds that if he makes an observation a night or two later, the shore-line will have encroached on the ocean of emptiness—a new strip of territory will be visible.

Direct sense impresses of an object are to be preferred to indirect ones. The telescopic view of the crescent moon is better than a photograph of it. To see the Grand Cañon or any other unusual piece of natural scenery is far preferable to any painting or word-picture of it. The heart-beat of the embryo chick, the actual forming of the salt crystal, the behaving of the real amoeba—all these take precedence of pictures, models, and descriptions. The real thing, as stimulus, affects the sensory nerves more powerfully than do these representations, and hence a more vivid and lasting record is made in the association areas. "To have seen it is to have provided for its recollection." Here is found one of the permanent justifications for the students' laboratory and for field study. On the other hand, no one should be disheartened and turned aside from

a purpose to acquire knowledge because laboratories are inaccessible and field trips necessarily few. All the valuable knowledge now a possession of the human race has been set down in books; photographs and diagrams have been summoned to aid description. From these books he who will may, after all, acquire a thorough acquaintance with any science.

Persistence of consciousness, p. 31, is closely paralleled by the prevailing persistence in stimuli which in turn affords invariableness in the resultant perceptions—provided that in certain classes of cases the sense impresses occur in sufficiently close succession in time; this proviso must be made in order to cover those cases in which growth, decay, mutilation, or other change, may occur in the stimulus. Our confidence that we may depend on such persistence is one phase of the great inductive inference based on experience: the uniformity of Nature.

For illustration: the calcite crystal here on my desk weighs 36.66 grams; at least it did when I weighed it ten months ago. But no accident has befallen it in that time, and one cannot suppose that it now needs re-weighing to see whether it may not be, say, 35 grams, or perhaps 40. One the other hand, the excellent freshly dug potato which I stored away for seed will probably not weigh just the same, certainly it will not look just the same, when I take it out of storage in May; yet it will retain enough of its October assemblage of characteristics to assure me that it is the same potato. As a much more extreme case, suppose twenty-one eggs, resembling one another as closely as possible, are put into a properly

heated incubator in which the initial temperature is maintained. If one egg is opened on the first day and one on the twentieth, to the uninformed observer the contrast would be so great that his senses would seem to be at fault; but if one egg is opened each day the intervals are sufficiently short so that the perceptions hold together and afford a continuous record of the development of the embryo of the chick.

By far the greater part of our practical knowledge—that concerned in maintaining bodily existence and well-being—is based on those perceptions which result from the direct action of stimuli on sense organs. But if all men, everywhere and at all times, had been contented with this practical acquaintance with the environment to which they were born, that is, if the exceptional man had not appeared, it is plain that the human race might have gone on for other hundreds of thousands of years, repeating the lives of their ancestors—fed, clothed, and sheltered, like those who preceded them. However, the man who wanted to have more, or do more, or know more, than his fathers, did appear: the man with super-animal greed who would take for his own at the expense of his fellows; the man who proposed leaving the home valley and the home fishing-waters and led the migration to new regions. Also, at rare intervals, came the third man who said: I want to know what has not been known before. In time he added: If I could only see better and measure more accurately I would know yet more; I want to measure times and spaces and forces: I want to

see the invisible—that which is invisible either because it is so small or so far away.

Certain great extensions of our knowledge have only been possible by the devising of instruments acting intermediately between the stimulus and the sense organ—notably the eye. These extensions appear as exact science, and prominent among the aids in making them are the telescope, the microscope, the balance, the spectroscope, and the camera. Seeing and measuring to a minuteness and accuracy quite impossible for the unaided eye, more than anything else, distinguishes the methods of modern knowledge from those of ancient attempts to know the external world. We know now of physical existences and relationships which must have remained wholly beyond our grasp except for the above-named instruments. For example, no eye has ever seen the extraordinary nebula in which the Pleiades are entangled, but the telescope and camera together have made us as certain of it as we are of the Great Nebula in Andromeda which is easily visible to the naked eye. The structure and behavior of such protozoan animals as *Euglena viridis* are disclosed to us by the compound microscope. The telescope, spectroscope, and camera, have united to compel light from the sun to bear testimony regarding the chemical structure and physical condition of the sun itself; and not only of this, our nearest star, but also of those vastly more distant suns—too far away to affect the life of creatures on this small planet except at one point: the kindling of a desire to know the nature and history of those stars. The imper-

sonal quality and unique service of instruments designed to bring cargoes of riches to human nerve terminals is well indicated by H. C. Russell, director of the Sydney Observatory, in speaking of the time when photography shall take the place of the astronomical observer; his work will then "be done by a new sensitive being, a being not subject to fatigue, to east winds, to temper, and to bias, but one above all these weaknesses, calm and unruffled, with all the world shut out, and living only to catch the fleeting rays of light and tell their story."

The vast extension of our knowledge due to instrumental aids sometimes creates the impression that instruments have to a degree superseded the sense organs; but it must be kept in mind that the finest and most powerful apparatus would be wholly useless lacking the seeing eye with its nerve connections to a cerebral home where understanding dwells. And this must suggest to us that instrumental achievement does not mark the boundaries of science. Beyond perceptions due to supplemented sense organs is a vast field of knowledge, based upon these recorded perceptions and hence inferential in character.

Max Verworn writes: "Of all the natural sciences, chemistry, in dealing with the atoms, penetrates deepest into the composition of the physical world. It must hence be employed in elucidating the composition of living substance, and thereby completing the preparation for an understanding of vital phenomena."[1]

[1] M. Verworn, *General Physiology*, p. 99.

If such is the rôle of chemistry, we may well turn to it to see how a chemist begins, and also to find illustration of what is meant by knowledge based upon inference from perceptions.

Joseph Torrey, quite at the outset of his *Studies in Chemistry*, discusses *vaporization* ("the departure of a procession of particles from the liquid surface"), defining *vapor pressure* as "the tendency of a liquid to pass into the state of vapor," and leading to a summary:

1. Any solid can be melted and afterwards vaporized, provided it will stand the necessary heating without being destroyed. If we attempt to melt wood, we find that it ceases to be wood and is broken down into other things before its melting-point is reached; and the same is true of many other solids.

2. Any vapor can be condensed to a liquid; and the liquid thus produced can then be frozen, by reducing the temperature sufficiently."

This author continues: "Solids, liquids, and vapors . . . all undergo change in volume, and as a rule they increase in volume (expand) when heated, and decrease (contract) when cooled. . . . Every solid and every liquid has its own particular rate of expansion. In the case of vapors, however, there is a very remarkable fact: when vapors exist out of contact with their liquids, and at temperatures far above their condensing-points they all show the same rate of expansion no matter what the vapor may be."

Air is a vapor "out of contact with its liquid," for it condenses to a liquid only at a very low temperature which is secured in the laboratory. Besides air

various other substances exist in vapor form at ordinary temperatures and pressures. Any such substance is called a *gas*. Some gases can be smelled, others have color, but certain others appeal to no sense unless we count resistance (pressure) offered by a mass of the gas to a body moving rapidly through it, or, what comes to the same thing, the push of a mass of gas when it itself moves rapidly against some stationary object. (A third case, experimentally conducted, will be mentioned presently). Even in these phenomena of pressure and push—unless the "body" involved with the mass of gas is a human body with its distributed sense of touch—the presence of the gas is inferred from the effects produced. If we see a tree in the act of being blown over, we infer that something possessing mass and velocity, and hence kinetic energy, is present and is causing the phenomenon. In such a case the gas makes no direct appeal to any of our senses and, indeed, since it lacks such appeal, our very great-grandfathers may have said the wind god was raging around and toppled the tree over.

The gas which has the greatest practical importance for us is oxygen, since most forms of animal life are dependent on it for existence. The physiology of these forms is that of an animal which has developed on a planet with a gaseous envelope composed of a mixture of oxygen and a second gas, nitrogen, underlain by a partial envelope of water which is a chemical combination of oxygen and the gas, hydrogen. We are so much "at home" in air that we do not realize its presence until especial or

abnormal conditions arise. Wind is an especial condition; an abnormal one arises when a person puts his hand close over the opening in the top of the chamber of an air-pump and pumping is begun; he is quickly, even painfully, in possession of evidence that something invisible is present above his hand and has weight, something material because it has weight. Yet this "atmosphere"—call it that—has no color, no smell, no taste; while a medium of sound it is not itself a source of auditory sense impresses; nor does it appeal to the mother-sense of touch except under such conditions as those referred to above. How do we know that air is a mixture of two gases? How are they disentangled? How are the characteristic properties of oxygen and nitrogen learned? How is it found that this oxygen—for physiological reasons the all-important constituent of air—is also involved in the composition of water?

"Strangely enough, although solids appear to be the most tangible form in which substances present themselves to us, the science of chemistry has been built up largely upon facts derived from gases, the least tangible, at first sight, of the three forms." Naturally, therefore, a teacher will begin with the study of gases. Torrey, who is a teacher, starts with an experiment in which a weighed amount of a certain mixture, upon being heated, yields a gas. The weight of gas given off is determined by the loss in weight of the mixture, and the volume of the gas is determined by collecting it and then measuring the vessel in which it is confined. Instead of entering here into an account of the series of experiments

which in due course answer the above questions relating to air and water, the reader is urged to obtain a copy of Torrey's text-book[1] and give it diligent study. (There are, of course, various other excellent elementary text-books in chemistry; but this one can be especially recommended to the student who must perhaps read alone, without a laboratory, and who reads with the ever-repeated question: How do you know?) The point to be made for the present purpose is that we do not see atoms, we need not even know a gas through any sense impresses which are directly referred to it as their stimulus. Taking apparatus for granted—with certain properties of matter, knowledge of which is borrowed from physics—the only sense impresses concerned in an experiment may be through the eye when a thermometer scale is read, or when a balance pointer is seen to indicate that the pans are loaded with equal weights. Certain conclusions follow the perceptions which arise—provided the experimenter is sufficiently intelligent.

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[1] Joseph Torrey, Jr., *Elementary Studies in Chemistry,* H. Holt & Co., 1899.

CHAPTER VII

LAWS OF NATURE

Certain universal affirmatives—resulting from an assemblage of several, perhaps many, instances of a given phenomenon—are known as *laws of Nature.* Thus the apparent break in the straight stick at the surface of the water is a case of refraction, covered by a law which has been disclosed through studies of the behavior of a ray of light as it passes from a medium of one density into that of another. This law is so exactly known that it can be stated in a mathematical formula. (It may be said in passing that the exact sciences seek final expressions of their knowledge in the compact, unambiguous, quantitative language of mathematics; that is, in formulas or equations, an *equation* being a quantitative proposition, and a *formula* the predicate (or subject) of such a proposition with the remaining portion expressed in some ordinary language).

The use of the term "law" in connection with the term "Nature," however convenient, is misleading, because the term so connected may not be recognized as being in direct contrast with our conception of law meaning statute. It is especially misleading when it carries with it the idea of "lawgiver." Nothing of the kind is meant or implied, as may be seen from the following definitions of the phrase "law of Nature."

"A brief statement or formula which resumes

(sums up) the relationship between a group of facts."[1]

"Wherever regularity of any kind can be traced, it is the custom in science to call the general proposition which expresses the nature of that regularity a law."[2]

"The laws of nature, when the mode of their discovery is analyzed, are seen to be merely the most convenient way of stating the results of experience in a form suitable for future reference."[3]

"A law in the field of science is a statement of the way in which things do invariably behave."[4]

"In nature there is no law of refraction, only different cases of refraction. The law of refraction is a concise compendious rule, devised by us for the mental reconstruction of a fact."[5]

It will be seen that all of these writers are in essential agreement in defining "law of nature"; they only slightly vary in language. It may well be contrasted with the lack of harmony among those who set out to define "civilization," p. 67.

Governmental law, on the other hand, is everything that a law of Nature is not: It is local, temporary, often in the interests of the lawmaking person or persons, it frequently recognizes classes, and not infrequently works injustice, it may be broken or evaded—often with impunity, and it is subject to

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[1] Karl Pearson, *Grammar of Science,* p. 97.
[2] John Stuart Mill, *Logic,* p. 348.
[3] W. C. D. Whetham, *Recent Developments of Physical Science,* p. 31.
[4] Constance Jones, *Logic,* p. 8.
[5] Ernst Mach, *Science of Mechanics,* p. 485.

amendment or discard. A law (statute) is described as "good" or "bad," what is meant by good or bad depending on the individual doing the describing—his concern with the law, his supposed interests, and his ethical attainments.

Not one of the items in the foregoing paragraph applies to the laws of Nature. Their unchanging character is attested by the vast body of evidence furnished by human experience. And these "invariable behaviors," grouped under the terms: mechanics, physics, chemistry, operate not only throughout one planet which may be merely one among many homes of organisms intelligent enough to recognize uniformities—they hold on all the associate planets with their satellites and on the sun, they extend to the most distant stars and thus seem to afford the basic conditions of the sidereal universe.

At this point one properly asks how we know that the laws of Nature possess these two characteristics: invariability and co-extension with matter. In reply we remind ourselves that we come by such a law not through any revelation or guesswork, but by summing up many instances. The instances themselves have been phenomena perceived; the perceptions have been stored, and later analyzed, compared, and summarized, appearing as an elaborated product of cerebral activity. Finally, this summary, as a working proposition, has been subjected to tests afforded by new instances not used in reaching it in the first place. The process may be made clear by considering the history of the discovery of one of these laws; the law of Gravitation is chosen.

The Danish astronomer, Tycho Brahe (1546-1601), made many observations of positions of the planet Mars. Kepler, as his assistant, fell heir to this material and proposed to himself the task of discovering the kind of path that Mars must be moving in to afford these positions. After years of incredible devotion and toil he found that the observations were satisfied only by an elliptic orbit with the sun in one focus. Kepler then made the induction: The planets move in ellipses having one focus in common, with the sun at that focus. He also arrived at two other conclusions—the three being now known as Kepler's Laws. The conclusions were true but the induction whereby Kepler reached them is at least questionable, for he did not investigate the cause of this behavior of Mars or test his induction by other planets, and hence he could not properly conclude a like behavior for the other planets. The discovery—immensely valuable as it was—stood as a fact for Mars; it was, strictly speaking, a hypothesis as regarded the other planets.

Sir Isaac Newton (1642-1727), knowing the results of Kepler's work, thought the sun must pull on the planets if they were to move in closed paths around it; he asked himself how this pulling force varied and—assuming that a planet was moving in a circle (a special case of an ellipse) around the sun—he found that the pull must vary inversely as the square of the distance of the planet from the sun; that is, if, for instance, one planet were twice as far from the sun as another, it would be pulled only one-fourth as hard. But Newton was more

cautious and more scientific than Kepler; he realized that he must test this inverse square idea. From time immemorial men had known that unsupported bodies fall to the ground; they never fall up or even sidewise. Newton reasoned: perhaps the earth pulls bodies—stones and apples and raindrops and so on—to it and pulls with a strength which is inversely as the square of the distance of the body from the earth; also, he thought, this pulling power must reach beyond the height attained by any object thrown upward, beyond the height of the highest mountains, and even to the moon; the moon would do to test the inverse square. Newton knew from experiment that at the surface of the earth a body falls 193 inches in one second; he also knew that the moon's distance is about sixty times the earth's radius. If, then, the earth's pull was inversely as the square of the distance of a body from it, the moon ought to fall toward the earth 1/3600 of 193 inches in one second of time; that is, 0.0535 inches. How far did it actually fall? By dividing the length of the moon's orbit, expressed in inches, by the time of the moon's revolution around the earth, expressed in seconds, the velocity of the moon is known and thence the distance it would go in one second if moving on a tangent; this distance, in turn, properly combined with the radius of the earth gives the distance which the moon—trying to go ahead tangentially—is warped from a straight (tangential) course by the pull of the earth; that is, the amount of fall toward the center of the earth. But the radius of the earth was not accurately known in

1666. Newton used too small a distance for the moon, computing that it fell 0.044 inches in a second instead of 0.0535 inches. An ordinary man—supposing he had carried the problem to this point—would probably have said the two quantities were in substantial agreement and then hurried off to announce his discovery to members of the Royal Society. Newton was far from ordinary; he regarded the disagreement between these results as at least indicative of some unknown element in the problem and "laid aside at that time any further thought of the matter." In 1671 Picard of France made a new and more accurate measurement of a degree on the surface of the earth, 69.1 miles replacing the previous accepted value, 60 miles. It appears that Newton did not learn of Picard's work until 1684; he then turned to his earlier computations, made the corrections which this more accurate value of the size of the earth called for, and the results then agreed: the amount through which the moon falls in one second is the amount through which it ought to fall if the earth attracts it with a force which varies inversely as the square of the distance.

The law of Gravitation, as disclosed in the first book of the *Principia*, may be stated: Each particle of matter in the universe attracts every other particle with a force which varies directly as the product of the quantities of matter in each and inversely as the square of the distance between them. (By "quantity of matter" mass is meant, and the word "attracts" implies that the force between two par-

ticles acts in the straight line joining them and tends to bring them together).

Excepting the law of Uniformity and the law of Causation (to be discussed later), which form a class by themselves and afford a foundation for all the other laws of Nature, this law of Gravitation is premier. No other one discovery has so extended man's knowledge of the universe. From Hipparchus to Kepler—a period of some 1700 years—there were those who desired and sought to understand the motions of certain heavenly bodies which we now know to be companion worlds of the earth; but they were baffled until Newton's achievement definitely ended the old astronomy and inaugurated a new one.

It only remained to multiply evidence that should test and verify the law through the employment of it in calculating lunar and planetary places both for the past and the future. For this purpose the invention of a powerful mathematical language was timely and fitting. One may now read, in the language of the calculus, the whole story from the premise of the law of gravitation to the formulas employed in calculating the many pages of positions of planets and the moon for record, year after year, in nautical almanacs and ephemerides. In the course of this long train of reasoning, carried on by means of mathematical analysis, three small and simple equations appear which, upon translation, prove to be the three laws that Kepler's labors had brought to light. These equations attest both the simplicity of the laws themselves and the power of

a notation which can express propositions of vast import so compactly and in such absolutely definite terms.

Using the formulas above referred to, a staff of skilled computators calculate and publish, several years in advance, the precise places that will be occupied by each planet at definite times; similarly, they figure out the positions of the moon in the sky for each hour of a future year. Every eclipse, whether solar or lunar, is announced beforehand with all its circumstances; the future occultations (eclipses) of a long list of stars are also figured and published in the same book with the eclipses and planetary places. Now, if the mode of behavior of gravitation were changeable—operating one way to-day, another way next year, and sometimes lapsing for awhile—conclusions based on the alleged truth and uniformity of this statement regarding gravitational force would be correspondingly unreliable. But matters turn out as the numerical propositions of the almanacs and ephemerides declare in advance that they will. For instance, official government almanacs announced a total eclipse of the sun, September 20, 1922, giving the circumstances of the eclipse, with accompanying charts from which the times of beginning and ending might be found for different regions on the earth where it would be visible. The preface of the *American Ephemeris and Nautical Almanac,* in which this information was published, is dated Washington, July, 1919. When the time came the moon did its part punctually and once more testified for the law of gravitation. If any com-

pany of far-journeying astronomers failed to see the eclipse, it was due to forbidding conditions in the earth's atmosphere.

To illustrate again, an occultation (eclipse) of the planet Venus, to occur January 13, 1923, was published in the official almanac dated July, 1920. The time of this phenomenon was given to tenths of a minute. The planet was occulted as predicted.

The youthfulness of the new astronomy may be realized by noting that when the Mayflower set sail the discoverer of the law of gravitation had not been born, not by twenty-two years. In 1620 a venturesome transatlantic boat—not to mention earlier and more venturesome craft—without sextant and without nautical almanac, sailed as she could and anchored where shore allowed. To-day, passengers crossing the Atlantic on an ocean liner do not expect the boat to fumble up and down the coast until she hits her proposed port, say New York; she sails for New York and, barring accident, arrives.

> "Safe comes the ship to haven,
> Through billows and through gales,"

not because

> " . . . the great Twin Brethren
> Sit shining on the sails,"

but because there is a sextant and chronometer and a nautical almanac on board, also one or two persons who understand the combined use of these things. And the passengers—most of them, at least—are contentedly ignorant of the connection between the safety and directness of their voyage and the work of the man who thought to calculate how far the moon falls toward the earth in one second

of time, on the assumption that the earth is attracting it with a force that varies inversely as the square of the distance through which it acts.

The apparent vagaries of mere weather may, for a long time, have interfered with the progress of the primitive mind toward anything like the idea of uniformity in the ways of Nature and hence toward a grasp on even the simplest laws. It is small wonder that early man, in his ignorance and fears and superstitions, clung to the notion of capricious super-creatures—the gods of the storm, the water, the thunder, the sun—that must be propitiated. But certain uniformities at length, though gradually, did force themselves on his attention through the tutoring of that first and last teacher, Experience. Beneath weather was climate and back of climate was the change of season. Summer always did give way to winter, and spring in turn followed winter; the trees leaved out again, the nuts and berries grew and came to be fit to eat. If a god did it, he did it by repetition.

Whatever have been the obstacles—in earlier times and later ones—not only to the discovery of "the ways in which things do invariably behave," but also to the recognition of that law (uniformity) which is both the basis of all the others and the final induction from them, the human mind is now in possession of them; perhaps it would be more correct to say they are in possession of the mind. The reliability and steadfastness of these uniformities are now so thoroughly assured that anybody would say that an instrument-maker, for instance, had "lost his

mind" if he reasoned: Before I make another sextant I must test the reflection phenomena of light and see whether the angle of reflection is yet exactly equal to the angle of incidence; perhaps it has recently changed. A captain would be deemed mentally unfit to take a ship out if he argued: I cannot trust this year's almanac; its computations were made three years ago. That is, intelligent people, whether they are acquainted with experiments and formulas or not, do rely on the quality of unvaryingness; they do not believe that these constant behaviors which we call laws can be changed by any accident, or the will of gods, or efforts of human beings.

The second property of the laws of Nature, namely, their co-extension with matter, is an inference which outruns the possible limits of experimental testing. We are disposed to make this planet—at least this solar system—the center, the all-important center, of the universe, and hence the field of Nature's condensed activities. But confidence in the limitlessness of Nature's reach is greatly strengthened by considering what is involved in a denial of it. To-day, in this laboratory, one atom of sodium combines with one atom of chlorine to form salt. We are mentally compelled to believe that such atoms combined thus, with the salt result, when life was not; and will do so beyond the time when the last of the human race experiments in any laboratory. Assuming the proper conditions for this special chemical action—as indeed they must be assumed for any place on the earth—just where, between here and Mars say, will sodium and chlorine re-

fuse any longer to combine to make salt? An appreciation of the nature of chemical action compels us to believe that, given the elements and conditions, the action will take place with entire indifference to the particular planet which offers the opportunity; it may be Venus or Saturn or any other member of the family of planets.

Again, the physicist finds that certain dark lines in the spectrum are due to light from a heated solid or liquid (or a gas under high pressure) shining through sodium, or hydrogen, or other element, in a gaseous state. These phenomena are all in his small laboratory and hence under his control. Suppose now the physicist becomes an astrophysicist with all apparatus the same as before except that the source of light, instead of being in the laboratory, is in the sun. Sunlight passed through a prism and caught on a screen (with suitable secondary arrangements) gives the same dark lines—that is, corresponding in place in the spectrum from violet to red—which had already been obtained using a light in the laboratory. In the next chapter it will be pointed out that some effects may result from one of two or more causes; but the astrophysicist does not believe this to be such a case; he unhesitatingly declares that our sun consists of an incandescent interior—doubtless a gas under enormous pressure—shining through relatively cooler gaseous envelopes. Why does he not concede that the laboratory effect when the light comes from the sun may be due to a causal arrangement of matter and kind of matter there which is wholly different from his laboratory

cause? He does not concede it, for studies of the origin of those dark lines as a purely terrestrial phenomenon, taken in connection with the great numbers of coinciding sun lines and laboratory lines—hundreds of them—make it highly improbable that the elements in the sun and the physical condition of masses of those elements are different from conditions and elements with which he dealt in his laboratory.

If the sun and earth are thus known to be composed of substantially the same elements, a common origin of the sun and earth is inferred. Using this inference in connection with certain striking facts regarding the solar system the astronomer concludes that the entire system had a common origin. The chemical composition and physical condition of the sun once established by means of the spectrum analysis of its light, it is evident that the composition and condition of other suns may be known provided their spectra can be obtained. Thus an astronomy post-dating but not supplanting that of Newton adds enormously to our knowledge of the universe. As a single example, the star Capella yields a spectrum so closely resembling the sun's spectrum that the astronomer believes Capella to be in essentially the same condition, physically and chemically, that the sun is in. On the other hand, such stars as Sirius and Betelgeuse are shown by their spectra to be in conditions very unlike that of the sun.

If chemists, physicists, and astronomers, seem to have outstripped biologists in attaining exact and

far-reaching results it must be referred to the more complex character of vital phenomena with the quite general refusal thus far of such phenomena to submit to mathematical treatment. Gravitation, kinetic energy, the relation between volume and pressure of gas at a constant temperature, buoyancy, the lever, and so on, appear to us in a quantitative aspect and hence offering that which can be measured. On the other hand, the behavior of an organism or the functioning of an organ is, as a rule, qualitative and therefore not subject to description in formulas. (As regards this term *behavior* we may properly speak, for instance, of the behavior of a crawfish as it snuggles into a damp crevice of disintegrating sandstone, or the behavior of wild geese in migration; but it is also convenient to speak of the "behavior" of a ray of light as it passes through a prism, or the "behavior" of water when crystallizing, or the "behavior" of a comet's tail as the comet approaches its shortest distance from the sun; but in all such cases the word is used figuratively—borrowed through the courtesy of the biological sciences).

To conclude this chapter: it is sufficient and meets the demands of brevity to answer "How do you know?" by pointing out that any given instance, or group of instances, or phenomenon, falls under such or such a law of Nature—provided it does. But not all knowledge is yet so summarized. Many facts, adequately established through sufficient evidence, have yet to be grouped and "explained," before one general statement, covering a whole group,

can be made. And further, many other facts are in their nature isolated and cannot be accounted for by reference to any law.

It is also necessary to note here the unwarranted use of the term law outside of the uniformities of Nature and the assemblages of governmental laws. Thus the word "law" in connection with the phrase, "supply and demand," would be misleading even if the so-called "law of supply and demand" expressed any general truth connected with the phenomena of economic life. Safety in thinking requires one to keep constantly in mind the characteristics of the laws of Nature in order that other alleged laws may not be invested with those characteristics and thence with the authority of a law of Nature.

CHAPTER VIII

Cause

Closely akin to the law of uniformity, both in method of discovery and in generality, is another law of Nature, namely causation. By this law we mean that any event or phenomenon, B, is preceded in time by some other event or phenomenon, A, which happening, B will happen; and failing to happen, B will not happen. B is called briefly an effect and A a cause.

Returning to those primitive ancestors—as we must, again and again, to find the explanatory clues to our own lives—it seems probable that through the experiences of many centuries it gradually dawned on the human mind that things do not just happen; they happen after something else which is not indifferently anything else. Even if primitive man thought that some events were due to the acts of unseen, sometimes unfriendly, beings he had therein the notion of something happening because something else had first happened. The simplest matters of daily life became the basis for the idea of cause. Food—berries, or bear-meat, or certain nuts and roots—relieved the feeling of hunger; lack of food was always followed by that gnawing feeling in a certain part of the body. Fire always destroyed the stick; it also affected the hand with a feeling that was worse than the gnawing of hunger; thus the man with the first fires learned to

avoid their contact with his body. Water falling from above did several things: it put out the fire, it raised the stream and wet the leaves and washed out footprints. Rain had effects, every time; what made the rain? Rain-god? Medicine-man?

Early man's mind did not "dwell on" this relational aspect of any event; nor was that man able to trace the succession of linkages of cause and effect whereby every effect becomes in turn a cause. His descendants to this day have a marked tendency to view events, A and B, in pairs and stop at that, though no pair is ever isolated; for cause A is the effect of say A_0 and B becomes the cause of C, and so on endlessly. With this must be noted a common tendency to simplify causal relations beyond any allowable degree.

Thus it is assumed that cause A is simple, whereas it is often compound, and by A we should mean a_1, a_2, a_3, . . . all contributing to form the total cause A and produce the effect B.

Among these contributing causes one may be more effective than the others, and it becomes necessary to determine which one is thus dominant; also, if possible, to note the order of importance of the remaining ones.

Further, these factors a_1, a_2, a_3, . . . may not all be independent of one another, but so connected that one, say a_2, reënforces, or lessens, a_1 directly.

As another case, a_1, a_2, a_3, . . . may be potential causes of B; the problem is to find which is the actual cause.

A and B may be so related that in many instances

special care must be taken to decide which should be called cause and which effect.

With A initially the cause of B, B may react on A, this reaction being itself a cause of change in A.

B may be a complex effect; so that it becomes necessary to analyze B to detect other immediate effects besides the obvious primary one.

Not infrequently, A and B happening together, or in close succession, one is assumed to be the cause of the other when in fact they have little or no causal relation.

In case A is recognized as a possible cause of B, its adequacy must be tested.

This summary is perhaps not exhaustive, but it covers the more common cases where knowing depends upon faithful examination of the connections existing in a group of phenomena. On account of its importance it is recapitulated in problem form:

1. A single pair of phenomena are supposed to be causally related; to examine the supposition.
2. Let A be resolved, if possible, into associate causes, a_1, a_2, a_3, . . . to discover the leading one and arrange the others in the order of their importance.
3. In a compound cause A, made up of a_1, a_2, a_3, . . . to discover whether any two (or more) are related so that one directly reënforces (or lessens) the other.
4. To note that a_1, a_2, a_3 . . . may be potential causes of B, and to single out the actual cause.
5. With certainty of causal relation, to determine whether A is the cause of B, or B the cause of A.

6. With A initially the cause of B, to discover any possible reaction of B on A.
7. To analyze B, as a compound effect, into its components, b_1, b_2, . . .
8. To show that the association in time and space of two phenomena does not necessarily imply a causal relation.
9. To show that A is adequate as a cause of B.

In illustration of these nine cases:

1. The inclination of the earth's axis of rotation to the plane of its orbit is the cause of the change of seasons.

2. All efforts to refer the great war in the second decade of the twentieth century to any one cause will doubtless be regarded, in years to come, as futile and unsound. It is, indeed, already seen that the cause was a compound one which must be viewed as an interlinked effect of still earlier causes. Which one of the component causes was dominant may wait to be disclosed and agreed upon.

As another illustration of 2, climate in any given region is the effect of a compound cause in which the major factor is usually latitude, and the minor ones altitude, prevailing winds, mountain ranges, nearness to large bodies of water, etc.

3. Undoubtedly the component causes of the great war are themselves causally related. Political, economic, and social conditions, which were not only antecedent but causal, cannot be adequately treated except by viewing them as coöperating.

4. A familiar and painful example of case 4 is a headache. Various circumstances or conditions are

capable of producing a headache; what is the actual cause in any given instance? It is well to know, if possible, before applying a remedy.

5. In his study of the life-history of birds Chapman writes: "We have the special instances of intelligent adaptation to changed conditions of life, and, most interesting of all, the relation between structure and habits, or the part played by a bird's habits in determining the form of its bill, feet, wings, and tail. Thus the Crook-billed Plover of New Zealand turns over or probes under stones and shells in search of food, not because its crooked bill makes an excellent lever or probe, but it has acquired a crooked bill through this habit. Again, the Gallinules of certain islands in southern seas are flightless, not because their wings are too small to support them, but because after having flown to these islands they had no further use for wings, which in time, through disuse, became so small that the birds have lost the power of flight. In other words, it is not because their wings are small that they do not fly, but because they do not fly their wings are small."[1]

Quoting from a letter which Thomas Jefferson wrote in 1823, Professor Beard makes the comment: "Thus Jefferson appears to believe that European governments rested upon a *theory* about the moral depravity of the masses according to which class rule was to be viewed as an instrument for the maintenance of public order, and exploitation was a mere

[1] Frank M. Chapman, *Birds of Eastern North America,* p. 4.

incident to the process. In other words, he reverses the facts in his history, for most scholars hold to-day that exploitation was itself the origin of the state and class rule, and that government and good order were incidental products."[1]

As an example of neglect of case 5, temperance reformers, in their zeal to secure prohibition, point to poverty as a result of the drink-habit, failing to notice that poverty may be, in very many cases, the cause of the drink-habit; and also that poverty may, and often does, proceed from other causes besides drinking.

6. Some anthropoid ancestor of man, born with a slightly better brain than his fellows—an advantageous variation—used his fore limbs, and especially the very extremities of those fore limbs, for grasping, climbing, holding, and holding on, used them more, and more effectively, than his fellows used theirs. This increased and varied use of the fore paw—coming to be a hand—reacted causally on the brain to its advantageous improvement. The better brain, first a cause, became now an effect, then a cause again, and so on.

7. It is already perceived that the effects of the great war are manifold—as well as far from being the ones sought.

8. Wealth and power come to a nation in which a given economic system prevails. A causal relation is assumed, and the wealth and power are thence cited in justification of the prevailing economic system.

[1] Charles A. Beard, *Economic Origins of Jeffersonian Democracy,* p. 418.

Compare illustration five, p. 41. Note also Sir Henry Maine's statement, p. 67. Maine leaves us in no doubt as to his view: he regards the development of civilization as an effect of substituting several (private) property for collective ownership. It is true that "the history of the two (civilization and private ownership) cannot be disentangled," but this in itself is far from proof that either is the cause of the other. Much more evidence than that offered in the Rede Lecture for 1875 would be required before reaching proof.

9. Illustrative of the inadequacy of cause is the fanciful idea that ice ages and other major terrestrial phenomena may be referred to sun spots which are, in turn, referred to some star in a disturbing electrical state. The failure to recognize the inadequacy of such a cause is probably due to lack of appreciation of the distance of the assumed disturbing star and the consequent thinning out spatially of its energy waves by the time they reach our system. The star (*Proxima Centauri*) nearest to us—according to our present knowledge—is yet so far away that light—traveling at the rate of 186,000 miles per second and requiring 8.3 minutes to come from our sun to us—would require 4.1 years to come from that star to us. Only a few stars are near enough to enable us to determine their light-years; that is, the number of years that light must travel after leaving any given star until it reaches our system. Our sun with its family of planets is no more isolated than stars in general, yet it is so remote from the others that adequate causes of phenomena on it,

and so on our small earth planet, cannot be reasonably looked for among the stars.

Attention to the nature of sociological phenomena, that is, all phenomena outside the physical sciences and the strictly biological ones, brings to light the necessity of noticing what these phenomena are composed of, and then the further necessity of sorting and relating the materials thus found, guided by the nine cases above stated. It is not too much to say that no one is fitted to deal with the problems offered by modern life until he addresses himself to the study of actual situations viewed as effects on the one hand and as causes on the other. Most persons believe themselves qualified—by the mere circumstances of citizenship—for the handling of complicated public matters, though they know quite well that they cannot become chemists or physiologists or astronomers without training. Nevertheless, "the people should rule over their political and industrial affairs, for these things concern them." This implies preparation for citizenship.

The nature of the problems of physical and biological science—as well as those of sociology—indicates that any adequate definition of the term science must include the idea of causal relations among phenomena. Although Powell, p. 72, does not use the word "cause" in his definition, he doubtless means it by the phrase, "relations of sequence." A body of facts, dealing with the same subject matter, lacks that organization which makes it a science so long as the concept *cause* is absent.

The conditional proposition: if A is B, C is D, dis-

cussed in Appendix I, p. 221, is now seen to be—under all ordinary circumstances—strictly speaking a causal proposition in which "A is B" denotes an assumed cause, and "C is D," its accompanying effect. The fact that we cannot affirm the consequent and thence conclude the antecedent was there referred to the second fact that doing so would involve us in an undistributed middle. We are now able to explain the matter from another point of view by reference to case 4, p. 113. The effect, C is D, may be due to other causes beside A being B; say A′ being B′. This uncertainty forbids our concluding, A is B.

In Appendix III the reversing of the conditional proposition: if A is B, C is D, was shown to be correct when the subject matter belongs to mathematics. In view of the nature of cause, this exchange of antecedent for consequent and consequent for antecedent means that mathematics does not deal with causal relations. Euclidean geometry, for instance, is a connected aggregate of facts concerning the necessary relations of lines and angles. But the relation is not one of causation. We may begin with any premise of line-relations, say a regular hexagon, and thence disclose an extensive body of other relations which are necessarily involved. The wide difference between geometry and algebra on the one hand and any science on the other is obvious when comparisons are made. The geologist, for instance, is compelled to view an anticline as an effect; he would scarcely turn the statement around and treat the anticline as the cause of a lateral thrust or pres-

sure in the earth's crust. He may, indeed, view it as a cause or contributing condition, but not as regards lateral pressure; as marking a new topography anticlinal-synclinal folds may give opportunity, that is, become an associate cause, for a new erosion system and thus of a further topographic modification.

In contrast with this reasoning of the geologist, a geometer, defining a rhombus as an oblique-angled quadrilateral whose sides are equal, proceeds to shows that this relation among lines and angles involves, among others, the further relation that the diagonals bisect each other at right angles. But he may equally well start with the assumption of two unequal lines bisecting each other at right angles, and thence show that the figure formed by joining the ends of these lines has the line and angle relations stated in defining a rhombus. Throughout the direct and reverse operations the concepts, *cause, effect,* were absent.

The law of causation, stated at the outset of this chapter, implies succession and order in time. An effect cannot be simultaneous with its cause, although the time interval may, in many classes of instances, be extremely brief. If two phenomena, A and B, are suspected of having a causal relation it must be known, either directly or inferentially, that one precedes the other in time; but mere precedence, while necessary, is not sufficient to establish the fact of a cause and effect relation. It seems superfluous to point this out; yet "After this, therefore because of this" (*Post hoc, ergo propter hoc*), is far from be-

ing an uncommon fallacy. It grows out of careless disregard of the need to find other connections besides those of mere sequence.

For convenient reference the more common fallacies growing out of misapprehension of cause are here tabulated:

(a) Mistaking A for the cause of B when the real cause is X;

(b) Mistaking A for the cause of B when a_1, a_2, . . . are joint causes;

(c) Mistaking joint causes a_1, a_2, a_3, . . . for independent ones when two or more of them may be mutually dependent;

(d) Mistaking A for the actual cause when it may be only a potential one;

(e) Mistaking A for the cause of B when B may be the cause of A;

(f) Neglecting the possible action and reaction between A and B;

(g) Mistaking A for the cause of B when both are effects of X;

(h) Mistaking association in time for a causal relation;

(i) Regarding A as the cause of B on the ground that B follows A in time;

(j) Regarding A as adequate to cause B when it is not.

CHAPTER IX

Origin and Nature of Mathematics

As shown in the preceding chapter, mathematics—judged by any complete definition of science—is not a science. In the account of the discovery and verification of the law of gravitation it was spoken of as a language of marked compactness and freedom from ambiguity, rendering an indispensable service in the statement of general propositions of quantity and in carrying on a train of thought involving such propositions. Making, as we must, a distinction between knowledge and the language in which knowledge is stated, the question arises: Is mathematics merely a powerful language, or is it also knowledge itself? In many connections it is both. For example, a series of multiplications and divisions is being carried on by means of logarithms; how do you know that you can use numbers, called logarithms, that way and come out with the right answer? You reply: A logarithm is a kind of exponent, and exponents are symbols of powers and roots of numbers; powers and roots are special cases of multiplication, direct and reversed; multiplication, in turn, is a special case of addition. It thus results that logarithms find their justification in very simple processes which the grammar-school pupil uses. The theory of logarithms passes muster as a body of knowledge—a very small body yet serving well enough to illustrate the curiously double rôle of the

train of formulas composing that theory; it is a language and the knowledge expressed thereby.

The same person who objected earlier to the proposition that all knowledge is based primarily on sense impresses is now likely to offer the syllogism:

(All) mathematics is knowledge;
no mathematics originates in sense impresses;
some knowledge does not originate in sense impresses.

This is seen to be satisfactory as a formal syllogism; its only drawback—for the purposes of any one who wants to establish the conclusion—is that the major premise is not true. So far as we know or can judge, mathematics does originate in sense impresses. To sustain this assertion evidence for it must be forthcoming; and this leads us to inquire into the probable experiences of the human creature who had yet to devise counting and measuring. As usual, in attempting a conjectural restoration of unknown phases of prehistoric social life, regard for the principle of greatest likelihood must govern us.

In the comparison of two objects to note likeness or unlikeness, that is, to form a judgment, the results are at first qualitative; in certain circumstances they may then become roughly quantitative. Hunger experiences must have taught the tree-climbing man animal to throw down many nuts or tree-fruits rather than a meager handful. If one fish partially appeased hunger two fish might completely do so; or a good-sized fish would serve as well as two small ones. The idea of inequality, arising thus in connection with food, would be reënforced by other ex-

periences: this man of the beginnings could fling the small stone which his hand easily grasped when he could barely lift the one that served to close the opening of his cave; of the streams that he wanted to cross some he could leap over—and he was probably a great fellow at leaping—other streams he was obliged to wade.

How did the idea of equality of quantity arise? It must happen that among pairs of objects—two stones to throw, two eggs to eat—instances would occur when one thing would be so like another that it would be impossible to "tell which was which." And the perception of alikeness would be preceded by, or accompanied by, the perception of number in its most elementary form: not one, but one and another one—duality as contrasted with unity. Once gained, this acquirement could hardly be lost, for the reason that daily experiences were of such a nature as to preserve it.

What would, sooner or later, be a following step? Two fish are caught, but the primitive fisherman can tell one from another; perhaps one struggled harder than the other, or the two have very different markings. Nevertheless they are otherwise alike: they both came out of the water; they are both cold; they smell alike, and alike they can satisfy hunger. Imagine the catcher of the fish attempting to convey the knowledge of his fisherman's luck—the how many—to his neighbor. The two fish have perhaps been eaten, or they are over yonder in the cave. How shall he tell that he caught two instead of one? He has as yet no words for *one, two,* though per-

haps a vocal symbol for fish. Two sticks from the ground, two little stones, or—more conveniently still—two of his fingers held up and supplemented by gesture language, give the help he needs. The sticks, stones, fingers, are temporary symbols of the fish, representing them numerically but in no other respect. (To this day the student at the college blackboard furtively counts on his fingers).

Simple enumeration may be defined as a registration of repeated impressions of any kind. If objects which we wish to count make a variety of sense impresses we ignore the unlike qualitative impresses and attend to each isolated one thing in order. For instance, if one has a handful of roses, some of which are large and red, others small and white, and others medium-sized very fragrant and pink, he disregards differences in size, color, fragrance, etc., and simply registers the repeated impresses made upon the organ of sight by the objects as distinct objects attended to one after another in time. Having completed this registration he declares the number of the roses. He could, of course, reach the same result in the dark by passing each rose in turn through the hand, thus using the sense of touch. Also, in the case supposed, he could by the sense of smell assert that there were two groups or kinds of roses.

In this operation we do precisely what primitive man did in counting his fish: we pass in time from one impress to another and note the individual records in the series. Practically we can count more roses or fish than our wild ancestor could, but that is

a detail; the great achievement is to count at all. As for the service rendered by sticks and stones and fingers in representing objects to be counted and in registering the completed count, it was the beginning; the end was the invention of ten symbols with the single convention regarding their arrangement. This invention is without a rival among the accomplishments of *Homo sapiens*—unless, indeed, we find one in that other invention: symbols to denote sounds of the human voice in speaking.

Returning to the origin of the idea of equality it is to be noted that the objects were put side by side when the experience arose of being unable to tell which was which. The closer two things are brought together, two colors in space, two sounds in time—provided that loss of their individual identities does not occur—the more readily and accurately can they be compared. The comparison can be most perfectly made in the case of linear extension, for the objects compared may then be placed in juxtaposition. There are no indications that we shall ever escape the need of putting one thing beside another in order to know magnitude in terms of chosen units. A quantity of grain may be measured with a bushel basket or a round box; but to know that it is a true bushel measure a graduated rectilinear scale must be used to determine the depth and diameter of the box and hence its volume-conformity to an accepted standard.

Weight is a gravitational phenomenon, yet weighing usually implies measurement by scale divisions of the two arms of a balance; the thermometer and

barometer also call for a graduated scale. Even the measurement of time—which would seem to be free from space relations—is found to depend upon space measurements of a special kind. The fundamental natural unit of time, the sidereal day, is the time that elapses between the transit of a star across a meridian and the next transit of the same star across that meridian (both transits being either upper culminations or lower ones). But this time corresponds to 360°, the angle through which the earth has rotated in this sidereal day; hence an angle measures the day, and fractions of that angle measure corresponding fractions of the day. Angles are space affairs; so it turns out that not only space phenomena but time phenomena are measured in terms of space units.

As conjecturally outlined above, arithmetic depends for its foundations upon sense impresses; counting begins with objects; measuring, from first to last, relies on sense impresses. But for the origin of geometry we are not left to a wholly conjectural restoration; the mental operations accompanying certain practices of men who lived near the dawn of history are disclosed to us through the Rhind papyrus, now a treasure of the British Museum. This manuscript is the work of an Egyptian priest named Ahmes who lived some time between 1700 B.C. and 1100 B.C. Ahmes' papyrus is "believed to be itself a copy, with emendations, of an older treatise of about the time 3400 B.C."[1] This Rhind edition

[1] W. W. R. Ball, *A Short Account of the History of Mathematics,* p. 4.

bears the suggestive title, "Directions for knowing all dark things," and consists of a collection of problems in arithmetic and geometry. From it we learn that the Egyptian of that day—and probably of a day long before—knew a few practical facts about related lines and the definite limited areas which they inclosed—barn-floors and fields; he had need to know, living as he did, in a valley regularly overflowed by a great and kindly river which was indifferent, however, to landmarks and boundary lines.

But the dweller in the Nile Valley did not "demonstrate" his facts; he did not say "any triangle," meaning thereby "all triangles," for he only knew particular triangles, this one and that one. It was left for Thales (born about 640 B.C.), to give geometry its start in its present deductive form. Going to Egypt, probably as a trader, Thales gained acquaintance with the geometrical knowledge current among the priests, and treated it deductively—some of it, at least. When he said, "The angles at the base of an isosceles triangle are equal," he was not making an induction from various instances of isosceles triangles; in his mind the idea had arisen that any given isosceles triangle is representative; a relation of lines and angles proved for it holds, consequently, for all of them.

This bit of history of mathematics brings out the sharp distinction between induction and deduction; it also assures us that man acquired his first geometrical notions through seeing and measuring; he had sense impresses of land boundaries and building

areas; he had other impresses that meant measurement.

The men whom the Nile induced to attempt earth-measuring were modern compared with those who first acquired enough brain power to count three; and it is the pre-dawn men, the beginners, who chiefly interest us for the purposes of this chapter.

Let OA and OB be two straight lines meeting in O at right angles to each other. Suppose a fox, running on the line OA away from O, is seen by a dog who is somewhere on OB. The dog gives chase, running at each moment directly toward the fox. It is clear that, because of the motion of the fox, the dog's path will be a curve. Why does the dog not take a straight line, directing his course ahead of the fox, say to a point C on OA, and aiming to overtake the fox just as the fox reaches C. We say that the dog cannot reason to that extent—wondering, however, whether a Highland collie might not be trained to do so. Would an anthropoid ape, or even *Homo neanderthalensis,* do any better than the untrained dog? Possibly so; perhaps not. We are forced to the view that somewhere in the long evolution an improving brain and enlarging experience were gradually attested by knowledge of a few most elementary facts about quantity, straight lines, distances, speeds, etc. The whole fish was perceived as made up of the pieces into which it had been cut with the stone knife. And the whole was more than any of its parts—more to carry and more to eat. There was one shortest way from the tree, under which some supposed man slept, to the nut-

tree on the other side of the wild meadow; by shortest he meant that running as fast as his fellows ran he reached the tree sooner than they did, following other courses. As already pointed out, p. 56, knowledge of this order was acquired by successive generations through imitation until a folk-lore stage was reached which permitted it to be conveyed by words and by acts intentionally instructive.

Compared with those youthful ten thousands of years of the human race the times of Thales and Euclid are very recent, so recent that the origin of certain special bits of arithmetical and geometrical knowledge was no more known to them than to us; it can only be conjectured; and no conjecture is defensible unless it refers to the simplest experiences of daily life. It is not meant above that the fact that "a straight line is the shortest distance between two points" was learned by racing to a nut-tree; it is meant that that kind of an experience is likely to have been the teacher. Euclid calls such knowledge *axioms,* while later writers give it the tag, "self-evident"; this term is expected to head off any inquiry as to how man came by this "self-evident" knowledge. It has been necessary, indeed, to discover the origin of man himself in order that the axioms of mathematics might be subject to investigation. One suggestive circumstance marks the conventional texts of geometry: there is not entire agreement as to the point where axioms leave off and theorems to be demonstrated begin. It is wholly possible that creatures with intellectual powers as far surpassing ours as ours surpass those of

primitive man would regard much, if not all, of Euclidean geometry as "self-evident"; that is, they would see at a glance the vast network of relations existing among lines and angles; the present laborious and often distasteful study of geometry would be unknown. Meanwhile any one lacking sympathy with, say early Pleistocene men, in their prolonged and tentative efforts to come by a few space facts, may acquire a fellow-feeling for them through solving a few problems like the following:

Given any plane triangle; on each side as a base construct an isosceles triangle with an angle of 120° at the vertex. If these vertices are marked P, Q, R, draw the lines PQ, PR, QR. To show that the triangle PQR is equilateral.

(No trigonometry or analytic geometry may be used; the work must be conducted wholly in Euclidean geometry).

To conclude; the basis of mathematics once secured through sense impresses its nature, as a connected aggregate of truths concerning quantity and extension, explains why no materials, specimens, observations or instruments, are needed—one might almost add, no books and no teachers. The effort to increase one's personal command of the subject must be wholly intellectual; there is no such thing as "authority"; the student's knowledge is built up piece by piece; if he skips connecting pieces, or if he does not grasp the series of steps from a starting-point—say the multiplication table or the unspecialized x of algebra—to a natural resting place, nothing can help him out, nor can he go on; he must

return and master the obscure piece of track. He "understands" the argument when he "sees" the necessary relationship of the successive parts.

All this is in sharp contrast with the study of science; because science not only requires laboratory equipment and field work, but in addition it deals with a far wider range of concepts and must employ a fundamentally different method in arriving at knowledge. It is more complex and more beset by pitfalls; it calls for intellectual effort plus; and always it is a search for causes or effects.

CHAPTER X

EVIDENCE

The various ways in which we use the term *fact* are shown by such expressions as the following:
(a) What are the facts in the case?
(b) How do you explain the facts?
(c) I am unacquainted with the facts;
(d) Nobody knows the facts;
(e) We shall never know the facts.
(a) implies that from the point of view of the inquirer the facts are unknown but knowable;
(b) means that the facts under discussion form a piece of knowledge, and explanation of them is sought;
(c) affirms that for the person speaking, the facts have not become knowledge;
(d) declares that not merely the speaker but all other persons are lacking knowledge in the matter considered;
(e) states that the facts can never become known, that is, can never pass to the status of knowledge.
To illustrate: suppose the question concerns the relative length of time which a heavy body and a light one will take before striking the ground if dropped from the same height.
Under (a) the fact is assumed to be common knowledge and readily stated.
(b) A person with the concept, gravitation, may explain the known fact regarding the times of fall.

In explaining he merely tells how terrestrial gravitation behaves: the earth pulls on each particle, pulls equally on each particle, and in one common direction. The fact, therefore, that the particles are stuck together into a mass, forming a given body, does not alter their individual behavior; hence, also, variation in the number of particles—that is, variation in its mass—does not affect the behavior of the body as a whole as regards the time of its descent; hence, finally, the heavy body and the light one will fall in equal times if dropped from the same height.

(c) Having never seen a heavy body and a light one dropped from the same height, and having no distinct notion how the earth pulls on bodies, a person may properly say he is unacquainted with the facts in the case.

(d) Before the time of Galileo it would have been quite correct to say: Nobody knows the facts about falling bodies.

(e) The relation connecting the time, height, and velocity, of a falling body of any mass, and subject only to gravitational force, being now a matter of common knowledge, does not belong to that order of facts which may be described as apparently unknowable.

But if it is now asked why gravitation affects each particle equally, or why the gravitational pull on particles or masses of particles—an aeroplane or a meteorite or the moon—is inversely as the square of the distance of the body from the center of the earth, it can only be said we do not know why; not yet, at least. Why does a body, not acted upon by

any outside force, remain at rest or move with uniform speed in a straight line? Why does sunlight acting on living vegetable tissue produce chlorophyll? Why is chlorophyll green? Why do hydrogen and oxygen unite in the ratio of two volumes of H to one of O to form water? We do not know why. Knowledge stops with the description of such facts as these. It is part of the business of science to explain—often if not usually—by searching for and disclosing that event which happening a definite something else invariably happens. But all explaining is merely resolving phenomena into more simple phenomena, though an ultimate basis of simplicity is never reached. Thus tropism (p. 18) explains various behaviors of plants and animals, especially of lowly forms; tropisms are resolved into several species and each species explained in terms of more fundamental phenomena; yet the explanation can never be carried so far that we can no longer ask: But how do you explain that?

The capacity for being surprised is closely related to power to take notice, and this in turn precedes desire for explanation. A cave-bear would probably have felt no surprise if the stream had turned and flowed uphill, but the hunter of the bear knew uphill; the going up was accompanied by certain muscular sensations; he had also found that up, as high as he could get, meant to see more trees and more hills; perhaps it also meant security. Going to an unfamiliar region he would have been surprised and baffled had he found the water running uphill; all the streams he knew in the homeland ran

downhill. But he was satisfied with the constancy of the river; desire to explain it did not waken in a mind as yet so undeveloped. It was a far descendant, a mentally venturesome person, who resolved gravitational force into two components, one normal to the river bed with a balancing reaction to that normal, and a second component along the bed, unbalanced and thus causing the down flow. But inquiring man with all his physics and mathematics has got no further; gravitation derides—as yet—his desire for explanation.

Evidence is fact in the rôle of proof or sign. When C is believed to be D on the ground that A is known to be B, A is B denotes the evidential fact. The idea that C may be D is in the mind first, and evidence is sought or offered to confirm (or deny) this idea. Many pieces of evidence have been given throughout the preceding chapters, but since attention has not been called to them in such a way as to bring out the nature of evidence itself, it is now necessary to give illustrations for this purpose.

1. Ernest Thompson Seton, in the Totem Board, February, 1920, tells the story, "The Papoose on the Squaw's Back." "When you know the story of the Bears and how the Big Dipper came, you should hear the Indian story of the Old Squaw. First find the bright star that is at the bend of the Dipper handle. This is called the 'Old Squaw,' and on her back is a tiny star that they call the 'Papoose.' As soon as an Indian boy is old enough to understand, his mother takes him out into the night, when it is calm and clear, and without any moon or any bright

lights near, and says: 'My child, yonder is the Old Squaw, the second of the seven stars: she is going over the top of the hill; on her back she carries her Papoose. Tell me, my child, can you see the Papoose?' Then the little Redskin gazes, and from his mother's hand he takes two pebbles, a big one and a little one, and he sets them together on her lap, to show how the two stars seem to him. And when the mother is sure that he did see them clearly, she rejoices. . . . Her child has the eyes of a hunter. These things are not new, O Woodcrafter. The wise men of our race call the Big Star Mizar, one of the chariot horses, and the little star Alcor, or the Rider. In all ages, to see this little star has been considered proof of first-class eyes. Can you see it? Have you the eyes of a hunter?"

Regarding this story it is worth noting that the Indian mother has teacher-wit and is willing to take pains with her pupil; her method is distinctly scientific. It may be believed that she proceeds as she does because it is so important to know whether the child has good keen eyes. She could easily thwart her purpose by simply placing the Squaw and Papoose pebbles in their proper relative positions, as Mizar and Alcor appear in the sky. But as she manages the matter the child cannot help giving evidence as to the quality of his eyesight. To subject the young Paleface woodcrafter to a like test Alcor should have been omitted from the Dipper diagram in the Totem Board. (The end star in the handle of the Big Dipper is *eta Ursae Majoris;* the next star is *zeta Ursae Majoris*—the big star Mizar

of the story. The reader might test his own eyes by looking for Alcor; it seems very close to Mizar.)

2. The phases of the moon are evidence that the moon is not self-luminous; they are also evidence that the moon revolves around the earth. This revolution, together with lack of self-luminosity, is the cause of moon phases; see 2, p. 113. We have here a case of evidence, cause, and explanation, in one phenomenon.

3. Rivers in the northern hemisphere, whether flowing north or south, are known to shift toward their right banks. A notable case exists in the great Yenisei of Siberia, flowing north into the West Siberian Sea. Nansen, who journeyed up this river from its mouth in 1913, speaks more than once of the evidence that the river has shifted eastward. This eastward shifting "must naturally lead to the river digging out its channel deeper on the right side of its bed, and also to its wearing away the right bank more than the left. In this way the whole river-bed has a tendency to move gradually to the right. . . . The result must be that in the course of ages the river leaves on its left side a flat country where it formerly had its bed and where it has left its deposits and on its right it will have higher land into which it has not yet dug its way."[1]

Analysis of a geographer's reasoning on such a phenomenon as the Yenisei affords, results in:

(a) Peculiar river-bank forms, attracting attention, and

[1] Fridtjof Nansen, *Through Siberia: the Land of the Future*, p. 72.

(b) calling for explanation.
(c) If a river were to shift toward one bank, such and such shore features might be expected.
(d) The shores of this river, showing these features are evidence that the river has shifted.
(e) The evidence in this case is stronger than a sign—it is proof that the river has shifted.
(f) It has shifted toward the *right* bank.
(g) What is the cause of its shifting; that is, how shall we explain it.

A geologist or geographer does not resort—naturally enough—to any astronomical cause until all supposable non-astronomical causes fail him. Study of earth conditions in the region of the Yenisei discloses none, past or present, to which appeal can be made to account for the behavior of that river. The rotation of the earth, however (an astronomical phenomenon), calls into play forces which, if not counteracted by other forces (winds, etc.) would cause a meridianal river in the northern hemisphere to shift toward its right bank (southern hemisphere, left bank); and this is accepted as explanatory of the shifting of the river in question. This is the procedure of the geographer; a geophysicist might begin by studying the earth's behavior as a heavenly body and—coming upon forces due to the earth's rotation—might predict that field observations would give evidence of a river's response to these forces. The latter student furnishes the general truth which the former uses as an explanation of an observed phenomenon. But both are reasoning deductively in their joint work; formally stated, it

turns out to be a hypothetical syllogism the categorical premise of which is furnished by the geographer. See exercise 6, p. 226.

At some point in the study of a phenomenon, or group of associated phenomena, with the object of explaining it or finding its cause, a provisional explanation or cause is framed, and, if possible, more than one. This is known as a *hypothesis;* hence, hypothesis is to be defined as a provisional solution of a causal problem. Any such solution must be tested by all the facts which can be brought to bear on the case; and these are of the nature of evidence for, or against, the hypothesis. One hypothesis must be pitted against another, and the survivor is the best one of the two; though further investigation may suggest a third better than either, and perhaps finally the true explanation.

An excellent illustration of the origin of hypotheses may be found in the work already quoted: *Through Siberia: the Land of the Future.* Dr. Nansen learned about a mammoth frozen in the tundra near the mouth of the Yenisei. The last of the great body remained until the spring of 1913 when it was carried off by a Russian government expedition. Nansen asks: "How did these large extinct animals, usually the mammoth, sometimes the woolly rhinoceros, come here? How did they meet their death? How can they have been frozen in such a short time that these gigantic bodies have been preserved?" In connection with his questions the author makes some comments which are well worth passing on: "Formerly it was an easy matter to ex-

plain such things. Then one only had to make a deluge or some other convulsion of nature put an end to the animals, after which a glacial period suddenly came on to freeze and preserve them. In our day we do not treat nature so casually. We think that even at a great distance of time, her behavior was not very different from what it is now. In the main the same processes have always made themselves felt."[1] The author presents three explanations (hypotheses) as offered by Middendorff, Schrenck and Nehring, and Brandt, with objections to them. He then offers his own—prefaced in characteristic modesy—"I should, therefore, be more inclined to think it happened this way." Dr. Nansen's explanation is in substantial accord with the views of Baron Toll, himself an explorer of the frozen North.

It now appears that we ran into evidence, hypothesis, and explanation, in chapter V when making our way to the proposition: Botanists use odor words sparingly. The quotation from Starling (p. 84) is in support of one hypothesis: the sense of smell in human beings is not highly developed; and according to that solution of the problem the explanation is to be found not in flowers or in preferences of botanists but in the physiology of the sense organs concerned.

One more illustration of hypothesis is here given: We have at least four interpretations of history: the political; the providential; the geographic; the economic. The first is the classic one, much employed by earlier historians who explained history in terms

[1] *Opus cit.*, p. 120.

of the doings of kings and warriors and popes. The second has been intimately bound up with the first; so intimately, indeed, that emphasis has been placed on one or the other according to the inclinations of persons who have believed in both; the second, however, being an interpretation based on assumptions regarding the supernatural, has properly no place in efforts to understand history by reference to the sole basis of knowledge — perceptions arising through contact with the phenomenal world. With the development of geographic science and a recognition of the part played by land- and water-forms in the careers of peoples and nations the third interpretation has been employed—and over-employed. Finally, the fourth hypothesis remains to be tested by a long and thoroughgoing examination of the facts of history. The hypothesis that is to survive, through justification by these facts, will no doubt involve, in varying proportions for different epochs and different regions, some elements that are economic, others that are geographic, and yet others that are political. To reach the truth, much attractive and alluring simplicity will have to be discarded.

When a hypothesis survives every test that can be devised and explains the phenomena in question, it passes to the status of *theory*. Thus a nebular hypothesis has fairly attained rank as a theory; we are reasonably sure that a spiral nebula was the mother form of the cosmical matter out of which the solar system was developed. The mode of formation of this nebula itself, and the details of the subsequent

formation of the planets and their satellites, are yet hypothetical.

Evolution, through the persistence of advantageous variations, of all life forms on the earth is now so clearly established that it is no longer a speculation or hypothesis; we properly speak of the theory or principle of evolution. "No scientific generalization is more strongly supported by thoroughly tested evidences than is that of organic evolution."[1]

Hypothesis must not be confused with speculation or guesswork. Anybody can speculate, but to frame a hypothesis worthy of test involves considerable, if not extensive, knowledge of the subject in question. That "one person's guess is as good as another's" is as untrue as it is plausible.

Belief is an involuntary acceptance of a proposition in view of evidence; consequently, the phrase, "the will to believe," is self-contradictory. We may choose to observe, and choose to know, but not choose to believe—whatever our desires and preferences may be in the matter. Belief ranges from surmise to conviction, depending on the available evidence, and also on one's degree of readiness to believe. "A wise man," writes Hume, "proportions his belief to his evidence." And Professor Huxley says, "Belief, in the scientific sense of the word, is a serious matter, and needs strong foundations."[2]

Faith, which implies absence of evidence, implies also a mental condition characteristic of the young

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[1] Council of the American Association for the Advancement of Science, 1922.

[2] Thomas H. Huxley, *Lay Sermons,* p. 366.

and immature whereby the need of evidence is not recognized. Because he does not know, and is not yet able to know, the child must temporarily depend on parents and other older persons. As a blind confidence faith may shade into a quasi-belief—matters are accepted on the word of those who are older and presumably wiser. But these "wise" elders themselves often do not know that the faith of trustful youth must yield to an evidenced belief as one approaches mental maturity. To preserve any faith by the maintenance of ignorance is a sufficient indictment of the faith itself and of those who thus secure its permanence.

The general term *inference* is given to the behaviors of the mind described in this and preceding chapters when, in view of A being B, we pass to C is D. C is D in this connection may represent: a cause, an effect, a sign, a proof, a hypothesis, an induction, a deduction. On the ground of certain facts or phenomena we infer something else. Examples of this series of less general concepts are of course examples of the inclusive concept, *Inference.* To those already given one or two may be here added.

The ceiling of a certain chemical laboratory once bore for years a wide-spread spattered patch as if acids or other staining substances had been thrown at it. A visitor inferred (guessed, assumed, concluded), a laboratory explosion at some time in the past. Upon inquiry his inference was confirmed by the professor's testimony: Yes, they did have quite an explosion once.

A geologist* of the United States Geological Survey, assigned to field work in the Southern Appalachians, was once looking, at the close of the day, for a camping ground for his party of five. Good water was a prime consideration; fire-wood came next. The road led to a ford where a little river swept around a wooded bluff; above the bluff there appeared to be an open field. Crossing the stream the geologist, habitually silent and observant, stepped out of the buckboard and said to his companion: "Drive on up and turn into that old field. There is a spring around the bluff; I'll just go and see whether it is all right"; and he disappeared in the thicket bordering the river. The buckboard and the camp wagon passed slowly up to high ground. Far across the field came the geologist waving his hat. "Drive in!" he shouted, "the spring is here." "How did you know?" he was later asked. "Oh, it was just obliged to be; notice the rock." Neither this leader nor any member of his party had ever before been in that particular region; nor had any information been obtained along the way. It should be added that no buildings were within sight; the spring was uncared for and seemed to be unused by human beings. A few hoof-prints and a faint trail indicated that cattle occasionally came there to drink. One might call it mere luck, a happy guess; but another would say it was a skilled geologist's inference as to what was probable.

Scientific prediction may be regarded as a species of inference if we assign to it a greater degree of

* C. Willard Hayes, 1858-1916.

certainty than attaches to inference in general; that is, the prediction becomes a statement of an effect in view of that which is certainly its cause. Thus if a star could be known to be coming toward us we could *predict* that the lines in its spectrum will be displaced toward the violet end. If, on the other hand, the lines are observed displaced toward the violet end, we *infer* that the star is coming toward us. This second conditional proposition expresses an ordinary inference; the first belongs to the exceptional type.

Much so-called thinking, the offhand conclusions of daily life, is marked by false inference. For instance, the doctor is seen coming out of a neighbor's house and it is at once asked: Who is sick there? The next person repeats the question in categorical form: Somebody is sick at Mr. A's house; and by tomorrow morning the neighborhood looks for a contagious disease card at the window. It finally becomes known that the doctor stopped at the house to ask Mr. A, who is a plumber, to come as soon as convenient and mend a leaking sill-cock.

It is a wise saying, attributed to Confucius: "Don't stoop down to tie your shoe in your neighbor's melon patch." On account of the general tendency to make false inferences no one can afford to scorn avoidance of the appearance of evil.

Upon analysis the false inference is usually found to involve a universal premise when, at most, the syllogism contains only a sub-universal and a particular; in which case the conclusion must be correspondingly limited (p. 218). A doctor's call at a house is not an invariable sign of sickness there.

The reader will find it an exercise worth while to collect instances of false inference and reduce them to the form of a categorical syllogism or a conditional one—remembering that he is now free to challenge the premises. Daily life, the daily press, general literature, offer themselves as sources for material.

Reasoning from *analogy* consists in comparing two phenomena (or groups of phenomena) and noting that they are more or less alike in several points and thence inferring that they are alike in the remaining points. Analogies are unsound and misleading when: (a) the like points are few compared with the total number of points; or (b) the like points are unimportant; or (c) a point inferred to be alike in the two phenomena is causally connected with the observed like points. Even after care has been taken as regards (a), (b), (c), the conclusion is only a probable expression of the truth.

As an example of a legitimate analogy, the earth and the planet Mars resemble each other in various pertinent particulars; it may be argued that Mars further resembles the earth in sustaining animal and vegetal life. But the argument falls far short of proof.

A little girl, who had never seen her baby brother travel around a room in any way except by creeping, called out one day in great excitement: "Oh, Mother, come! The baby is standing up on his hind legs." An admirable and sound analogy.

The greatest, because most important, of all analogies is one person's inference of consciousness in

another (p. 33). The points in common—physical structure, needs, behavior—between one normal human being and another are such that each infers the existence of consciousness in the other.

Reasoning from analogy requires more skill and alertness than do other forms of inference; and it must be remembered that, in general, analogies are treacherous because in their nature they are plausible and often it is far from easy to point out the fatally weak spot in one. Kropotkin speaks warningly of "the slippery ground of mere analogy."

The term analogy is often carelessly used to mark what is only an illustration; hence illustrations also need to be sharply watched. While *instances* serve, as already indicated, in the several forms of inference, *illustrations* proper never contribute to the proof of a proposition; their part—supposing they are well chosen—is to throw light on what might otherwise remain obscure through being abstract.

One peculiar case of forced inference may be expressed in the form: A must be B because of what is involved in the denial that A is B. An example has already been given, p. 106. Another example is found in the statement: "We are not certain, using certain in the strict sense, that the Angiosperms are the lineal descendants of the carboniferous plants, but it is very much easier to believe that they are than that they are not."[1]

Finally, in conjectural restoration of an irrevocable and almost wholly undocumented past, of sev-

[1] William Bateson, *Evolutionary Faith and Modern Doubts,* Science, 1922.

eral possible solutions possessing varying degrees of likelihood, that must receive favorable approval which has the greatest likelihood, with the reservation that under the circumstances it is no more than a view—not a hypothesis because it does not admit of test; and certainly not a theory, which, as already shown, only arises as the result of a hypothesis successfully surviving adequate tests. Thus it seems likely, it is a reasonable view to hold, that some of man's earliest efforts at naming were imitations of sounds made by the objects to be named. Again, some human creature at some time made the very great physiological discovery that a child has a father as well as a mother. In all probability this discovery was made by a woman. The likelihood is that circumstances would aid her, as they would not aid a man, in arriving at this fact.

But conjectural restorations, alluring as they are, relate to what must so far baffle the student that he cannot say he knows; he can only match one likelihood against another.

CHAPTER XI

Knowledge Through Testimony

If the reader will review one of his average days —or one of his years by means of journals and other records—and select all knowledge which he has acquired at first-hand in that day or that year, he may well be humbled to note how little he has learned by himself regarding the environing world. The value of exercising as a personal right what was with primitive man a necessity has been too little esteemed; and hence too easily invaded by insistent givers of information. One may, indeed, fall in with some rare Nature teacher who practices the self-restraint of the Indian mother—a teacher who will leave the learner to himself to locate Alcor, to track the moon among the stars for a month, and to discover the time of the witch-hazel's blooming. But in general both his power to observe and his power to deal adequately with observations, in case they are made, are endangered by the "teaching" to which he is subjected throughout life.

Obviously any individual's stock of knowledge falls into two groups: one due to his own sense impresses and perceptions, and the second to the sense impresses and perceptions of others and hence second-hand. The method of the first group has such especial value—over and above the knowledge itself—that whenever possible, without unjustifiable cost in

time, its results should not be left to be secured by the method of the second group.

One marked characteristic of civilization to-day is a vast store of what purports to be knowledge and which has accumulated during recent centuries. For each member of society this knowledge is necessarily second-hand. Even if one has made large and valuable inferences he is usually indebted to others for the basic material. Our knowledge of distant parts of the world, especially those parts which we have not visited; our knowledge of all past events, especially those prior to our own lifetime; our knowledge of investigations in laboratories and observatories, together with the work of the geologist and oceanographer—all must be described as second-hand. Plainly, therefore, its reliability—and hence, in part, its value—depends upon the competency and veracity of those whose senses we are using in place of our own, and whose elaboration of perceptions we accept as warranted by their sense impresses. Both the training and the ethics of these reporters must be considered. A man may be competent to report facts, and yet he may be careless, he may be biased, or he may have a motive for misrepresentation. Another may have the desire and intention to tell the truth, but he may be untrained in accurate observation and be lacking in the habit of making correct inferences, and hence be inadequately equipped for reporting. How are we to know when reports are dependable?

The difficulties in acquiring knowledge of the past reside in the fact that it is past. The actors are

gone, with much of the libretto; their curtain is down; they have left us little enough from which to reconstruct their opera—especially the chorus; for the historical records so largely ignore the part of the common people—slaves, thralls, serfs, peasants, proletariat—that the partial restoration of their life, increasingly important as that life now seems in historical sociology, must always leave us baffled by the reflection that our knowledge is most incomplete and uncertain.

However, some past is so recently past that occasionally a quick-witted historian gets an account of the last act of a period from the *dramatis personae* themselves. An exceptionally good illustration of the timely collection of evidence relating to the recent past is afforded by the work of Siebert in writing *The Underground Railroad from Slavery to Freedom*. This book was published in 1898, that is, thirty-five years after the Emancipation Proclamation. There were then living men and women who could remember the years preceding the Civil War. Professor Siebert consulted not only all available printed documents, but secured in various States the reminiscences of persons who had been connected with the Underground Railroad or had observed it in operation. He justly points out the unusual trustworthiness of such testimony:

"It would be difficult to imagine an 'old-time' abolitionist, whose faculties are in a fair state of preservation, forgetting that he received fugitives from a certain neighbor or community a few miles away, that he usually stowed them in his garret or hay-

mow, and that he was in the habit of taking them at night in all kinds of weather to one of several different stations, the managers of which he knew intimately and trusted implicitly. Not only did repetition serve to deepen the general recollections of the average operator, but the strange and romantic character of his unlawful business helped to fix them in his mind. Some special occurrences he is apt to remember with vividness because they were in some way extraordinary. . . . The risks these persons ran, the few and scattered friends they had, the concentration of their interests into small compass, because of the disdain of the communities where they lived, have secured to us a source of knowledge, the value of which cannot be lightly questioned."[1]

Very much more of the knowledge of the cultured man is acquired through the printed word than through the oral one. It is more than the whimsical occupation of an idle moment to try to figure out one's mental condition if one had never learned to read—assuming, of course, that no special effort had been made by others to give oral instruction. Such a person might have much good judgment as respects daily personal and neighborhood affairs; excellent wit and knowledge of a valuable practical sort; his mind would be fortunately free from a quantity of worthless matter that would otherwise drift into it from the printed page. But with this said it remains true that to-day the bulk of knowledge is stored in convenient external form which

[1] W. H. Siebert, *The Underground Railroad from Slavery to Freedom,* p. 11.

may be handed around or packed away, and to avail oneself of the form one must master the system. Here on white paper are stamped symbols, each one representing a sound made by the human voice in speaking. These symbols are arranged in small groups and the group becomes the symbol of a word —the name of a thing or an act or a quality. These word symbols are in turn arranged in groups—the space order on paper agreeing with the time order in speaking—so that expression of a judgment results. Finally, a grouping of these judgment symbols denotes a train of thought. These significant markings on paper thus become stimuli affecting the organ of sight (or indirectly the organ of hearing) through which they leave their imprint in the recording tracts of the cerebrum, or arouse images already present in the associative memory.

The only remaining question is: Does a given series of images and their relationship as created by the serial order of printed words agree with what would have been my own perceptions had I been in the circumstances in question, namely, the circumstances of the person who saw the persons and shared the events thus historically preserved.

For example: using my eyes on printed pages in various books, I have perceptions, and thence images, signifying that at a certain time, in a certain country, there lived a man named Julius Caesar. I "read" about the circumstances of his early life and education and about his career. I even read a book which purports to have been written by him. Am I to take these books about Caesar "on authority"?

Whose authority? How do I get authority for authority? How am I to distinguish between tradition and folk-tale on the one hand and authentic history on the other. I want to know without being either obliged to become myself a research student or involving myself in the risk and stupidity of taking some one person's word for it. Regarding the illustration just instanced and all its class it is clear that no general rule for guidance can be given; but it is helpful to note that:

(a) majorities—even majorities of the learned—are not always in the right;

(b) in recent times, with increased freedom of thought and increased recognition of what constitutes impartial investigation, scholars are disposed, more and more, to leave no documentary stone unturned in arriving at facts;

(c) if investigators are still in disagreement among themselves the ordinary searcher after truth will do well not to let his own views pass beyond the stage of lightly-held opinions.

Returning to Caesar, he is a fairly easy problem; controversies do not rage around his laureled head. To set him aside with the heroes of fiction involves like disappearance from the world of the real of too many of his alleged contemporaries and with them Roman literature, government, and conquest. It is easier to believe that Caesar lived when it is claimed that he lived, that his career was what the documents of his supposed century and later centuries hold it to have been, than to believe a denial of it. In a stubborn spirit of challenge—which has

in it a nucleus to be approved—we might claim that the *Commentaries* are a forgery, at least that there are interpolations due to enemies and designed to throw discredit on the great Caesar. Thus we read: "Caesar tarried for a few days in their territory until he had burnt all the villages and buildings and cut down the corn-crops." (*Gallic War,* Bk. IV, chap. 19). This becomes a matter of internal evidence; but even casual reading shows the passage quoted to be a fair sample of many strewn throughout the work. Few books exhibit such consistency and unity as do these memoranda. Their alleged author, writing in the third person, draws no dim or wavering picture of what a man becomes and is capable of doing who devotes himself to the attainment of power for the sake of power and to the winning of glory through military conquest.

Across the Mediterranean, more than four hundred years after Caesar's time, lived Hypatia, Alexandrian teacher. Commentaries that she perhaps wrote would be priceless now. Why do we know so little of her life and teachings? The Muse of history can only speak sadly of the dealings of an unkind age with this heretic of the fifth century. Papyrus rolls were burnt as ruthlessly as Caesar burnt Gallic homes; and ashes record nothing except the devastation of fire. Hypatia's lecture notes—irrevocably gone—suggest like losses, known and unknown, that can never be made up to us who live on the hither side of the Middle Ages.

As regards all treasures not lost there must arise questions of genuineness, authorship, interpolations,

copyists' errors, etc., and, as already suggested, the necessity of distinguishing between dependable history and folk-tale or forgery. If "the researches of modern investigators have bereaved Robin Hood not merely of his earldom but of his humanity," referring his very name to that of a mythical forest-elf, why may not John Ball, ecclesiastical and political heretic, be similarly disposed of. If the dramatic incident of William Tell's apple-shooting is mere tradition, why not so classify the records of a Swiss revolution which resulted in the "Everlasting League" of 1291. If certain plays credited to Shakespeare may be challenged, why not some section of Newton's *Principia*. One might go indefinitely with illustrations of this sort. We are here confronted by the perplexing question of historical evidence; and it is to be said that we can give no answer to the demand: How do you know? if all we have is the very doubtful "authority" of some mere compiler who is making statements not only at second-hand, but third- or fourth-hand. The task of the serious student is plainly not that of reading a single book; it is that of comparing, sifting, and choosing; discarding one book for a better, one authority for another. Turn the problem as we will we cannot escape the troublesome fact that one must know much in order to know whether historical propositions are probably true or more probably false. Yet this should not be permitted to lead one to abandon the study of history; there is always the prospect of increasing skill and surer tread in ill-

lighted trails, with the promise of the leadership of experts.

How shall the expert be recognized? His first and last qualification is gone if he cares for aught except the facts in the case. Whether he deals with old books or old violins, with pictures or fossils, with ruins or time-defaced inscriptions, he must have no speculation to champion, no glory or fame to seek, and, above all things else, no financial reward in view. Freedom from dogmatism and devotion to evidence are unfailing marks that serve in identifying the pathfinder who has qualified intellectually and ethically.

History, usually and more naturally a knitting-up, seems to call also for unraveling—proceeding in the reverse order of events in time; because the existing state of civilized society throws a reflected light on the preceding state. We know—or may know—this present; it instructs us as to the immediate past. Any generation, viewed as a social array of effects, backs—so to speak—into a preceding era. One advantage of this reversed study is found in the necessity of attending to all the strands that combine in the weaving of human life-phenomena: economic, industrial, educational, religious, as well as political. The Industrial Revolution, for example, must be viewed as an effect, the cause of which is a marked case of compound cause, some of the contributing causes being of recent origin when referred to that revolution, and others more remote. If the Industrial Revolution were known in no other way it would be discovered in an inquiry into the causes

of certain social phenomena subsequent to it. Or, going further back for an illustration, it may be seen that certain matters find their explanation in outstanding features of the dark ages; and we have then to ask: What caused the dark ages?

But whether chronological order, or the reverse, be followed, all effort to reconstruct the past requires us to be sure, or reasonably sure, of documents from point to point. By the term "document" one means not merely a printed page, but a building, a coin from a river-bed, a piece of inscribed papyrus, a brick with artificial markings, a heap of shells, a picture on a cavern wall, a fish-hook, a fireplace, a stone ax, and so on. These are not hoaxes or freaks of Nature. To him who studies them faithfully with their context they speak of their own times and their makers.

It is necessary to turn now to a wholly different and vaster subject—that great modern body of organized, causally related knowledge called science—which must be taken by any individual largely on testimony, the aggregate testimony of those who know certain branches at first-hand. The difficulty here is not the scarcity or questionable value of old books; but rather the overwhelming amount both of data and inferences, with much of it of a technical quality and exacting in its demands on whomsoever would understand it. Two features especially mark science to-day: its extensive development along many lines, and its system of coöperation. What is now known of Nature, including man, far exceeds the acquirement capacity of any one person. He who

has achieved a respectable knowledge of a single science finds himself reasoning from analogy that every other science, equally with his own, is exacting as regards its demand for time and devotion. The astronomer or geologist gratefully accepts the aid of the chemist and physicist—satisfied that their work is fundamental and of far-reaching importance. The neurologist or anthropologist knows his indebtedness to zoölogy and through it to the two fundamental sciences, chemistry and physics, again. The points of contact and, indeed, the actual linkages of any one science with various others are now so many and varied that the idea of the unity of Nature emerges, and the assembled variously named parts are seen to form one organic body of truth.

The much scoffed-at "smattering" of science is far from valueless when it is made to consist in acquaintance with elements and principles rather than scraps of information; for only so does the student get at first-hand some notion of the connections above indicated. College students taking an adequately balanced course in "liberal arts," even students in high schools which are competently administered, have opportunity for the smattering of the kind here advocated. But what is the plain man whose necessary business in life is primarily labor to get food, clothing, and shelter—what is he, if eager to know, to do in the situation? In reply it is to be repeated that books, if not teachers and laboratories, are abundant. Any man with purpose can begin at the very foundation of some science and proceed as fast and as far as he masters each step. Speed is not

important but understanding is. What science it shall be must depend upon taste and opportunity. For the pursuit of certain ones the wide out-of-doors is a branch study-shop; for others, a table and equipment within four walls is sooner or later indispensable. When the worker begins to suspect that beneath the obvious applications of science there are fundamental principles, known only to the initiated, he will ask for more than is presented by the popular lecturer in his night school; he will say: "Give us, too, apparatus and specimens; let us see, and learn face to face, this which we hear about." This means, of course, a transfer of learning from the method of testimony to that of direct observation. Yet even if one is so fortunate as to have appliances most of his scientific knowledge must be taken on the testimony of others; the life of the individual is too short to admit of any other plan.

The method of science, including the grounds on which the testimony of men of science is accepted, will be discussed in a later chapter; meanwhile it may be said here that to understand how master students proceed in research one should read their own accounts of their investigations. For this purpose there is probably no book more helpful than *The Life and Letters of Charles Darwin,* edited by his son Francis. Darwin did not command elaborate equipment, and for his work such was not necessary; but it may be doubted whether he has ever been surpassed in what is called scientific temper. The story of his life ought therefore to be familiar to every one who wants to know how we know.

The *Life and Letters* may well be followed by *The Origin of Species,* a book of commanding importance in the history of science, yet so clear and simple in its presentation of the author's argument that the earnest student, trying to discover the secret of the method of science, must place this book at the head of his reading list; he must not be long obliged to confess: I have never read *The Origin of Species.*

CHAPTER XII

Pseudo-Knowledge Through Opinion

In the preceding chapter emphasis has been laid on the need and difficulty of determining the competency and truthfulness of those whose testimony we are to accept. It was assumed that the testimony relates to alleged facts in the past or the present; that is, it was taken for granted that there were actual circumstances containing sources of sense impresses and thence of perceptions. These perceptions and their correct inferences, being conveyed to us without mutilation or modification, become our own knowledge.

We have now to consider another class of propositions, categorical in form, framed and offered by persons gone or yet living. These judgments or propositions are expressions of *opinion;* hence they differ widely from direct testimony based on evidence. The categorical form arises apparently from two causes: desire for economy combined with desire for more pleasing rhetorical dress; and from fear that propositions provisionally stated will be weakened in effectiveness. The writer or speaker is loath to be continually prefacing his statements with such expressions as: "In my opinion," "I think," "I believe," "As I look at it." The unfortunate result is that the undiscriminating fail to remind themselves that the statement is mere opinion; they do not dis-

tinguish between it and knowledge; consequently the average mind is choked with pseudo-knowledge.

Opinion abounds in interpretive and exegetical writing, in literature, philosophy. and theology; also in much, if not most, of the writing on social topics, including politics and ethics—appearing in the sermon, the editorial, and the "article." The degree of acceptance accorded all this matter is closely proportioned to the fame and reputation of its authors. The favorite editor, the eloquent preacher, the clever essayist, the popular office-holder, never lack admiring and mentally submissive hearers and readers. The dogmatic character of this literature of opinion, so far from giving offense, is pleasing; its sinister quality is disclosed, however, in the behavior of multitudes of people who have never learned to say: What is your evidence? Give me your facts and I will form my own opinions. In all this discursive matter, so highly esteemed in "cultured" circles and fashionable educational programs, evidence is either taken for granted or dismissed as quite superfluous. It is not realized that the popular imposing writing is mainly a product of temperament, prejudices, motives, and early bias, and that its chief relation to truth is only too often one of contrast. Opinions are valuable when they stimulate inquiry or promote independent thinking of one's own; over and above this, they consume time and unfit the mind of the hearer or reader for its proper exercise. Further, the social importance of these masses of *ex cathedra* views grows out of the fact that opinions often conduct to desires, and de-

sires prompt to action in harmony with the opinions. Hence we have social action—frequently of far-reaching consequences—underlain by mere "views" which are themselves unsustained by defensible evidence.

It is hoped that the above will itself be challenged as "mere opinion"—in order to induce the reader to take up some culture magazine, a book of essays, an editorial page of any leading daily, to go to the nearest church next Sunday, also to the next club meeting to be addressed by a popular speaker; this program with the definite intention of noting what per cent., approximately, of what he reads and hears can fairly be set down as knowledge or justified as inference from undisputed facts.

A sharp distinction is here to be made between opinion and fiction, that is, products of the imagination whether expressed in prose or verse; a certain range of imaginative writing is not to be lightly valued or readily discarded. It is, for example, a grave loss to fail to read *Medea* and *Hamlet* and *Romola, Rob Roy* and *Les Misérables* and *A Doll's House.* Such gifts from genius are indeed to be gratefully accepted at the full measure of appreciation of which one is capable; what he is capable of depends on several personal variables which in turn depend on the individual degree of mental development. But, unless fortified in advance by much private reflection and the power to resist opinion, another person's interpretation is intrusive and obstructive. To read and re-read and study half a dozen such books as the six above-mentioned, to con-

sider the characters, their words and acts, will go further in the interests of genuine culture than any number of lectures about them. In fact, such lectures, however excellent, from however high an authority, so far from being an aid, defeat the object of the author discussed and deny the rights of him who should read for himself.

When opinions on any debatable subject are to be heeded, writers of various and opposing views should be given a hearing; and all of them—unless they reveal the basis for their views—are to be regarded with caution if not suspicion; out of what soil have their opinions grown? To take a definite example: Andrew Lang opens the first chapter of his *Social Origins* (1903) with the statement: "The Family is the most ancient and the most sacred of human institutions; the least likely to be overthrown by revolutionary attacks." This is rather positive language to start out with; so positive, indeed, that we might suppose Mr. Lang to be merely stating a well-established fact; and the reader is liable to submit at once to a dictum so sweeping and high-sounding. But on the second page the author admits that there is a difference of opinion and says that "the difficulty of the subject cannot be exaggerated; for the origins of our human society cannot be historically traced behind the institutions of the races now lowest in the scale of culture." Authors expressing a differing opinion are not far to seek: Bachofen, MacLennan, Kovalevsky, Kropotkin, and others, give evidence in support of a view

quite at variance with Lang's. Kropotkin[1] sums up the counter-position of these anthropologists to the effect that the *clan*—also a human institution—long antedated the family. Furthermore, one word in Lang's initial statement betrays him—so far as it may be taken in evidence—as a writer of sentiment rather than science. He says the Family is "the most sacred of institutions." In what sense can he possibly be using the term "sacred"? By any fair and legitimate employment of the world, the history of institutions shows that the "family" has been, and is, anything but sacred. And as regards its being "the least likely to be overthrown by revolutionary attacks," Andrew Lang, writing at the beginning of the twentieth century, should have been aware that whether it be called revolution or evolution the family as an institution is undergoing profound modifications due not to "attacks" but to social, notably economic, changes which no hand can stay. Nevertheless the impressive pronouncement of the author of *Social Origins* will be welcomed by many as an expression of a "great truth," its greatness being directly proportioned to their predisposition to believe it.

Finally, it is important to note a very different use of the term opinion occurring when it marks the conclusion or judgment of an investigator who therein sums up some result of his study. Thus Mach, as Loeb points out, has expressed the opinion that chemical conditions lie at the foundations of sensa-

[1] P. Kropotkin, *Mutual Aid a Factor of Evolution,* Appendix vii.

tions in general. On what grounds do we place confidence in such an opinion when expressed by Mach—a type of opinion lying wholly outside the field described in this chapter. We do so because, as we become increasingly familiar with the literature of exact science, we find that Ernst Mach is regarded by the makers of that literature as one of the profoundest students of physics; it appears that his contributions to the *Analysis of the Sensations* and *The Science of Mechanics* are works to be reckoned with by any one who sets out to acquire a more than superficial acquaintance with the subjects discussed in them or to make any advance in the lines to which they open.

The nature of these exceptional judgments may be further and sufficiently indicated by referring to one more of the master students in science. In a work already quoted—*Comparative Physiology of the Brain*—it will be noticed that usually when Professor Loeb expresses a belief or a view or an opinion he does it in immediate connection with the evidence therefor. The trail of the argument is thus continuously guarded and the wayfarer realizes the intellectual honesty of his guide: Here is the evidence; here is what I infer from it.

To conclude this chapter; a few rules in connection with opinion may well be followed:

1. Is this discourse fact or opinion?
2. In the latter case is the opinion careful judgment framed in view of an ample set of facts?
3. What are the facts?

4. Is the writer or speaker free from prejudice and fear, with liberty to speak his own mind?

5. It is not necessary to hold an opinion—our own or an adopted one—in matters respecting which we have little or no knowledge.

6. Views—one's own—are to be held tentatively, subject to revision upon the acquirement of more facts. (And this change is not to be confused with fickleness or "having no mind of one's own").

7. Opinions from various sources, bearing on a given question, must be accorded a hearing.

8. The will to challenge, as a mental habit, is to be cultivated, not in order to be disputatious or hypercritical, but because there is probably no person writing or otherwise teaching—outside the field of exact science—who does not make statements which may be, and ought to be, questioned; and this in proportion as the teacher deals in opinions. The world has not yet known an omniscient or infallible leader in knowledge, or in thought inspired by knowledge, one who could rightly claim exemption from the demand for evidence.

CHAPTER XIII

Fallacies

The term *fallacy* has been used in Appendix I to denote violations of the six rules which govern the syllogism. Also, at the close of chapter VIII, (Cause), ten cases of erroneous treatment of causal problems are tabulated; these likewise must be classed as fallacies. From the two groups here mentioned it appears that, briefly stated, fallacies are mental misbehavior; manifestations which are the sign of under-development of the mind, a liability to confusion, a failure to detect pitfalls in reasoning. This account of the nature of fallacy will be verified in considering a third important, though more miscellaneous, group some of the cases of which are as follows:

1. Fallacies of observation, in a sense, lead all the rest; they are of two kinds: non-observation and mal-observation. Bain says regarding them: "The one leaves out pertinent instances, the other distorts or misrepresents what is observed. Non-observation explains the credit given to fortune-tellers, to quacks, and to false maxims; the cases favorable being noted, and the others forgotten. The motive in this class of fallacies is a strong pre-conceived opinion or wish to find the dictum true. Under mal-observation may be placed the chief mistake connected with the proper act of observing, namely, the confounding of a perception with a rapid inference,

or the mingling up of inferences with facts. This is the common infirmity of uneducated witnesses and narrators of events."[1]

Another phase of non-observation is disclosed in the fact that positive cases usually make so strong an impression on the mind that one neglects to compare their number with the total of cases or instances. The hits are counted but not the misses. Thus, for example, one makes no note of the negative instances, the times when he saw the new moon over his left shoulder and no bad luck followed. Again, the belief in an autumnal equinoctial ("line") storm grows out of the failure to observe the non-occurrences of any unusual storm about September 23.

2. Failure to prove that A is B is taken as a proof that A is not B. For example, no lines of the element nitrogen have yet been identified in the solar spectrum. The student is liable to interpret this as final proof that nitrogen does not exist in the sun. Failure to furnish evidence that other worlds are inhabited by intelligent creatures is taken as proof that such extramundane life does not exist. Failure to prove that the "soul" is not immortal is accepted as proof that it is immortal. The fallacy in all such cases consists in not reflecting that other unknown causes, unreached as yet by observation or experiment, may exist. Thus the question of life in other worlds is a highly speculative one with little or no evidence one way or another; we are reduced to rea-

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[1] A. Bain, *Logic: Deductive and Inductive,* p. 601.

soning from analogy under the guidance of likelihood. All we are entitled to say is, that it does not seem probable that this one insignificant planet is the only heavenly body which has afforded both the conditions and cause for the appearance and development of that which feels, takes food, grows, and dies.

3. A form of confusion occurs when capability of one sort is carried into other departments and interpreted as fitness there. For instance, the ball player by his expertness comes to be regarded as potentially an expert in other matters; and hence his training as a player or an athlete is accorded an undue degree of value; instant reaction to a situation—essentially automatic from long practice—on the competitive athletic field is confusedly assumed to be somehow convertible into that sure and important mental action: clearness of perception of social relations, sound reasoning and good judgment, demanded by the real exigencies of life.

4. Irrelevancy is another form of confused mental behavior. Thus if the topic under consideration is the danger of getting hurt by automobiles, or the evils resulting from the tobacco-habit, it is irrelevant to point out that there are other ways of meeting accidents besides those due to automobiles, other habits resembling the tobacco-habit in injurious effects. To bring other matters into the discussion draws attention from the subject in hand; the other points may be true but they are irrelevant.

"You, also" (*tu quoque*) is usually regarded as a variety of irrelevancy. Strictly and impersonally,

the character and conduct of A, who has perhaps lodged charges against B, or opposed argument to B's argument, has nothing to do with the case; the sole question turns on the accuracy and appositeness of A's statements. At the same time, suitability—not to say fairness—insists on an accompanying attention to A's behavior, including his motives. For example, when publicists, men of letters, and men of science, in England, France, and the United States, spoke with scorn of the behavior of a certain ninety-three distinguished Germans[1]—also publicists, men of letters, and men of science—in 1914, the formci might soon have been properly rebuked by *tu quoque;* they too—most of them—were swept frenziedly into the war-mind which never analyzes, rarely reasons, and seldom looks ahcad.

5. Another tendency to confusion is implicitly recognized and guarded against in Amendment IX of the Constitution of the United States: "The enumeration in the Constitution, of certain rights, shall not be construed to deny or disparage others retained by the people." The natural tendency is to suppose that any enumeration is a complete one—what is not mentioned is not meant; whereas the apparent enumeration was made not with a view to being complete, but probably to give prominence and explicitness to certain rights.

6. The fallacy of *averages* may be classed as one of confusion. Average wages are liable to be thought of as minimum; whereas, even if the aver-

[1] G. F. Nicolai, *The Biology of War,* p. xiii.

age seems sufficient for a given standard of living, many individuals toward one end of the scale may suffer great privation, while at the other end the "wages" (salaries) of a few may be excessive. The idea slips into one's thinking that somehow the poorest paid have this average wage. Average rainfall may involve drought and flood. The average depth of a stream may provide room to drown. In superficial studies of the distribution of a nation's wealth "average income" is peculiarly misleading.

Lack of clearness of thought in the much trampled-over field of averages finds only too many illustrations like these given; although the arithmetical meaning of average would seem to be simple enough: a quantity greater than each member of a series of quantities, and less than each member of another series, and derived from all the members in the simple well-known way; yet after securing the average the mind seems to lose sight of the extremes.

7. What is plausible often results in a confused failure to ask, Why? "A woman who is a mother will make a better teacher than one who is not," with the related assertion, "Only persons who are parents should be elected to the school board," are instances of a fallacious plausibility which intercepts all discussion. Besides entire propositions such as the two given, phrases—used as a tag is used—save the tagged proposition from challenge or examination. "It stands to reason," "obviously," "as everybody knows," "it is generally admitted," are of this nature. Also single terms serve the purpose of confusing the mind; "preparedness," "undesirable" citi-

zen, are in evidence as illustrations. The slogan finds its proper classification in this paragraph. Even when started for praiseworthy ends, the effect of the slogan—by arousing group excitement, if not prejudice—creates a kind of intellectual stupefaction and hence inability to resist; whether the "deadly yell" of demagogues or the summons of high-minded leaders, it finds expression in action which is not intelligent and which is frequently to be regretted in the sequel. Illustrations will readily occur to the reader.

8. "Begging the question," that is, assuming an unestablished point, is a common fallacy closely related to the one just described. It often appears in the form of an adroit phrase or a pretentious adjective, the quality of which may not be clearly recognized by the writer or speaker himself.

An instructive illustration of case 8 occurs in the article, "Slavery," Encyc. Brit. "It is in the communities . . . which were directly organized for war that slavery had its really natural and appropriate place. And, as war performed an indispensable function in human history, our just horror for some aspects of slavery must not prevent us from recognizing that institution as a necessary step in social progress." The author of the article begs the question in using the term "indispensable," and as slavery went with war he proceeds to beg the question a second time by calling slavery a "necessary step in social progress." Fallacious reasoning of this variety often gets by because the will to challenge is paralyzed in the presence of "authority."

9. Again, reference will be made to the "principles of human nature," as if such principles had not only come to light but were known beyond dispute. "Principles" is here an imposing but serviceable term to cover up extreme vagueness of thought, while its more dogmatic form, "You can't change human nature," sufficiently betrays, on the part of the speaker or writer, his large ignorance of mental evolution.

Further, the "instinct of patriotism," the "instinct of religion," and the like, are invoked effectively; for neither the person using these phrases nor, usually, the one hearing them seems to realize that there are no such instincts. The appeal to "instinct" may well be classed as one of the most common and most convenient of the fallacious tendencies of the mind; it provides an easy way to an "explanation" and saves further study. Now and then it snares the very elect. Thus Maurice Parmelee writes: "The plays of the boy seem to reveal the presence in him of the hunting or combative instincts, while the little girl playing with her dolls reveals an early awakening of the maternal instinct."[1] It is curious that a writer on instinct should himself be tripped by a fallacious instinct-hypothesis. Professor Parmelee seems to have failed to observe that from his earliest years a boy is taught both by precept and example to "stand up and take his own part"; fighting is "manly"—and he wants to be a man. But fighting is not "nice" for a little girl.

[1] M. Parmelee, *The Science of Human Behavior*, p. 249.

Dollies for her; dolls at the age of eighteen months, and dolls' clothes—miniature imitations of her own early finery—without respite; and when she, like her brother, responds to the teaching to which she is subjected we hear "maternal instinct," and "instinctive" love of dress. But all those persons—fathers and mothers, with occasionally a sociologist—in whose minds is embedded the "instinct" explanation of the difference in the tastes and activities of a boy and a girl are not likely to analyze the case, much less to make the only experiments which can settle the question; they are comfortable in a plausible fallacy.

10. A generalizing tendency—to be sharply distinguished from induction—takes its place as one of the common forms of mental misbehavior. Many persons are not at ease unless they are using universal propositions. Limitations, qualifications, exceptions, are felt to render conversation and formal discourse and writing dull and uninteresting. Exaggerations and sweeping statements give, for the moment, a commanding and quasi-heroic quality to the person who makes them. A twofold explanation arises for this restiveness and rebellion against the toning down of propositions to the lines of truthfulness: the one already mentioned, namely, the desire to speak impressively; and, second, the mind not inured to the effort to be exact finds it far from pleasurable or easy to secure the qualified statements which the case usually calls for.

11. The average man cannot easily bring himself to be impersonal, and to this fact must be

ascribed not a few of his ill-judged actions and indefensible beliefs. All his mental activities, whether of thought or feeling, cluster around himself; life is viewed from his standpoint and his supposed interests. The successive concentric circles of which he is the center are: his family, his club, his church, his "set," his class, his country. Human life one or two thousand years ago, or in China to-day, or in the factory and mine where his dividends are made, does not interest him. We should not expect to find —nor do we find—him searching for the meaning and explanation of human phenomena; he lives for himself, sufficient unto himself. Though he travel much he remains provincial. He cannot make allowance for the Negro, the Indian, the Oriental; their habits and institutions and languages are ridiculous; their minds are of course inferior to his own.

12. The tendency to anthropocentric attitudes toward environing Nature is a racial trait resembling the self-centeredness of the individual. We are disposed to interpret the features of the earth as addressed to human interests; the ongoing of geographic and climatic phenomena is considered wholly as it bears on human life. Hence, yielding to this anthropocentric tendency, we fail to see that the human race is not above Nature but is an incident in the history of the earth. The artificialities of civilization, inducing man to suppose he has differentiated himself into a superior creature, are essentially as "natural" as the nest of the bird or the dam of the beaver. By no possibility can man wrench himself from his origin, or dispute his de-

velopment as a reaction to his environment. The earth is not "for" him any more than it is for his fellow-animals, the beasts of the fields and woods. He has not "conquered Nature," he has only learned some of her unvarying modes of behavior and adjusted himself to them; failure to recognize this must be attributed partly to the superstition of providence and partly to racial conceit; its invariable result is erroneous thinking. The world of vegetal life is not green because "green is good for the eye"; the eye has developed in a green world, and over and above its optical conformity to the nature of light (p. 9) it has conformed to what we call "green." The obliquity of the ecliptic is not just what it is in order that man may have a desirable change of seasons; the angle between the earth's rotational axis and the plane of the earth's orbit merely takes its place in the list of like angles for the seven other planets; thus with certain initial differences in the positions and movements of the planet-making materials the earth's axis might have been practically perpendicular to its orbital plane, or inclined to it at a small angle. It pleases human creatures to believe that the actual angle has been selected out of consideration for their climatic well-being. Acquaintance with biology, geology, and astronomy, promises rescue from conceits of this kind.

13. Closely related to egoism and the anthropocentric point of view in promoting fallacious behavior, as noted under 11 and 12, is the perverting influence of the feelings. Thus Bain writes: "That

men believe according to their self-interest hardly needs illustration. Not only does each man endeavour to deceive others, he generally succeeds in deceiving himself when his interests are at stake. We have all great difficulty in seeing the faults of an institution that we profit by; the arguments of a highly paid priest for his own form of religion, or of a lawyer for lucrative forms of procedure, are regarded with suspicion. The grossest forms of error, the most noxious practices will be vindicated by persons whose worldly position depends on them.

"Among the particular pleasures and pains making up the great aggregate of self-interest, we may signalize some as especially unfavorable to truth. Indolence, or the aversion to labour, the source of so many moral obliquities, is the parent of intellectual error. The ascertainment of truth demands a kind of labour which the average human being dreads and abhors, hence the acquiesence in such views as come easiest to hand."[1]

Professor Bain also remarks that "the influence of aesthetic qualities—beauty, sublimity, harmony, propriety—is constantly operating to twist the understanding. The architecture, music, and colouring employed in religion, indispose the worshipper to canvas the validity of the doctrines. The art of the orator involves the tickling of the sense, and the charms of style. Such subjects as History, Criticism, Morality, the Human Mind, where literary polish is more or less attended to, are liable to distortion

[1] A. Bain, *Logic,* p. 610.

through this circumstance. Of Rhetorical devices, only a few are subservient to truth; while a great many are hostile."[1]

14. The temptation to ignore distasteful counter-evidence is so strong that we permit ourselves to think that the evidence in hand is sufficient when it is favorable to the view which we prefer. Men speak out of the fullness of their prejudice and bias more generally than they or others suppose; their minds are hospitable to those illustrations which support the affirmations which they are disposed to make. "His (Kontouzow's) experience had taught him the untrustworthiness of hearsay, and he knew, too, men incline to draw inferences that fit in with their desires, and to ignore everything that contradicts them."[2] And in a similar strain Hume writes: "Men run with great avidity to give their evidence in favor of what flatters their passions and their national prejudices."[3]

15. To the mischief wrought by the intrusion of an emotional factor into a field which should be kept free from emotions must be added the harm that results from a misunderstanding of the nature of the emotions themselves. Although purely subjective —testifying concerning themselves and themselves alone—they are accorded value as giving evidence concerning that which is objective, and, as one result, objective existence is ascribed to subjective creations. This tendency has been effectively exploited

[1] *Opus cit.*, p. 614.
[2] L. Tolstoy, *War and Peace,* Vol. III, Bk. 2, p. 127.
[3] David Hume, Letter to Gibbon (Gibbon's *Memoirs*).

in all religions and has lent itself to the purposes of literature.

16. A final group of hindrances to sound mental behavior may be marked by the term *superstitions*. Some of the leading ones are as follows:

(a) Precedent. Once a new and possibly suspicious measure, every current precedent has acquired an unchallengeable and tyrannical quality by dint of holding on; it seems to share the honor and power of "the Past" merely because it originated in the past; it may be unfitting and unreasonable, but the mind yields to its unsustained claims. The counterpart of precedent is fashion which, adroitly adjusting itself to precedent, is even the more tyrannical of the two. Conformity is coercive; few persons have the courage to refuse to obey fashion whether in clothes, or behavior, or beliefs, or opinions.

(b) The printed Word. Respect for the printed word—almost any printed word—as contrasted with speech, verges into superstition. Certain books acquire the status of fetish; this is especially true of such works as are deemed to be of divine, or quasi-divine, origin. Next to them rank books of religious and philosophical teaching; their constant readers are far more ready to swear in the words of some adopted master than to seek—even timidly—any adventure in thinking for themselves. Incidentally it is a test of the writers of these revered books to examine how far they are willing to do without followers if discarding discipleship is essential to unhindered mental growth for the possible disciples.

(c) Position. A person holds a high office and

the fact is accepted as evidence of his fitness for it. Generals and premiers and prelates go by and the crowd roars applause or bows in deep reverence. Worse than this honor and deference to the official, we give an extravagant degree of credence to what he says because he holds the office. "The king can do no wrong" has a companion doctrine, "the king knows because he is king." Thus we assume that when a man is elected or appointed a judge he sheds those limitations, prejudices, ignorances, and frailties, that were a part of his nature before reaching the bench; the office itself has in some mystical manner re-created him. With exaggerated importance credited to position in State and Church it is not remarkable that the holders of these positions are regarded as supermen who cannot make mistakes or be in the wrong. The extension of this concession to the "ruling class" generally is fatal to the development of the plain common man; for his mental submissiveness is then fairly typified by his bodily obedience.

(d) Providence. One looks in vain for any other single element in human life which has so continuously and powerfully operated to delay the improvement of the mind as has the idea of providence. It hardly needs to be pointed out that in all ages the race has not only been contented with, but has welcomed, supernatural explanation of phenomena both physical and social. These phenomena being in accordance with the designs of the gods search for other explanation is not to be thought of. The doctrine of providence has forestalled efforts to im-

prove conditions of living and has paralyzed the hand that would introduce justice into the ways of humanity; it has been the convenient refuge of wrong, the excuse for misery and disaster. In place of purpose to better affairs that are ill there has been supplication with sacrifice and resignation. It is no matter in what time or land we seek illustrations, they are found only too easily. Turning to Homer, for instance, he may be heard reporting the knightly Nestor as saying: "Now doth Kronos' son vouchsafe glory to this Hector, for the day; hereafter shall he grant it to us likewise, if he will. A man may not at all ward off the will of Zeus, not though he be very valiant; he verily is mightier far."[1] In later ages Attila is the "Scourge of God." While other cities are besieged and lands laid waste by this "Fear of the World" Rome is saved through miraculous interposition. In due time a World War is widely accounted for in essentially the same spirit as that which marked explanations in the fifth century: the great war is deemed part of an inscrutable "Plan," conveniently and devoutly referred to an extra-human origin.

But it comes to this, that the individual and the race alike have to choose between the faith that the world is engineered through the will of gods, and the belief that it is a vital ongoing through an ever new linkage of causes and effects. A careful study of the results of the faith, on the one hand, and the fruits of the belief, on the other—as disclosed by

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[1] Homer, *Iliad,* VIII, 141-144.

historical sociology—should aid in making the choice.

The subject of fallacies may be suitably closed with the summary observation that the human mind, in its present stage of development, is averse to recognizing things in their relationships; analysis requires effort, hence it is avoided; and affairs are believed to be marked by a unity and simplicity which they do not possess. Further, the ethical development of the race, like the intellectual, is so immature that without training it is natural to violate truth by inaccuracy and exaggeration, to indulge in partiality toward whatever is pleasing, and to entertain chiefly such views as harmonize with pre-conceived opinions. It is hard to be fair to a bitter foe —and harder yet to seek truth when the results of that seeking may run strongly counter to what one would like to believe as true. But an understanding of the fallacious tendencies of the mind is a long step toward acquirement of skill to avoid mental misbehavior.

CHAPTER XIV

Scientific Method

An outline at this point of what is known as *scientific method* can be little else than a recapitulation of what has been said in preceding chapters. While each chapter is reasonably complete in itself, all of them together furnish the rules which must be observed, the errors which must be avoided, if one is to come by knowledge, or use it to gain further knowledge, in a way that is proof against effective criticism.

As has been repeatedly pointed out, the series runs: stimuli, sense impresses, perceptions, provisional explanations, tests, inferences, more tests. These stimuli range from a multitude of apparently trivial unconnected matters to those that proclaim their own vastness and perhaps importance. How shall we boil potatoes, or grow maize, or make a hygienic shoe; how recover the essential facts in social conditions which resulted in private ownership of land, how account for the origin of a backbone in one great class of organisms, how interpret spiral nebulae.

One may try different ways of boiling a potato until he hits upon a method that gives the best results; if he is asked why that method gives the best results he can only answer: "I do not know why; I only know that is the way to do it." All practical purposes may be thus served, but this cook is un-

scientific because he explains nothing; he is satisfied with a rule of thumb. To resolve the phenomenon of potato-boiling into more fundamental phenomena —that is, to explain it—calls for equipment and knowledge which most persons neither command nor desire.

Explanation usually involves association of that which is to be explained with kindred phenomena; that is, the bringing together through classification of like things, conditions, events; and this operation further distinguishes scientific procedure from the mental activities of the rule of thumb person who only knows facts as isolated.

Any problem of a kind to invite explanation falls into one or the other of two groups according as its affiliations are physical or biological—including in the latter group the entire range of sociological phenomena. As shown in speaking of induction, p. 83, a corresponding difference arises in handling the problem, due to the circumstance that biological phenomena, especially in the sociological branch, requires more facts, more cases, and more regard for the likelihood that compound causes are present. This cannot be taken to mean that either the physical sciences or the biological ones are the more scientific; the indispensable method, in its large outlines, is the same in the two. As already noted, various problems in the exact (physical) sciences, instead of calling for the collection of cases hitherto unobserved, do require many measurements of the same quantity and thence the computation of the "most probable" value. (The reader is warned against

supposing that this most probable value is a mere average of many slightly discordant measurements). The determination of "g" in physics, the determination of the latitude of any place on the earth, the determination of the most nearly accurate value possible for the distance of the sun—as problems in astronomy—are important illustrations.

Chemistry, physics, and astronomy are dependent on instruments and apparatus. New apparatus suggested by the nature of the problem—the material expression of a new idea—may become, in the hands of persons capable of originating these ideas, powerful means for explaining old facts or acquiring new ones. Happily for the extension of knowledge one investigation often, if not always, leads to, or suggests, another; the investigator comes upon a new country when he merely went out to round up the live stock. Thus "the conception that atoms consist of central positively charged nuclei of small dimensions surrounded by one or more systems of electrons whose aggregate charge of negative electricity exactly neutralized the nuclear positive charge, arose in an attempt by Rutherford to explain the large angle scattering of *alpha* rays obtained when these traversed thin foils or sheets of various metals."[1]

In general, and briefly stated, scientific method comprises five parts:

1. Phenomena recognized as requiring examination and explanation;
2. Collection of cases or relevant facts (observation), and, whenever possible, experimentation;

[1] J. C. McLennan, Science, Vol. LV, p. 219, 1922.

3. Provisional explanations, one or more, suggested by the material in hand; with adequate tests by means of all available facts;
4. In the absence of any explanation which stands the tests, postponement until further study or additional facts suggest some new hypothesis. A hypothesis which survives testing is accepted—provisionally at least—as the true solution; although other facts brought to light later may again throw doubt upon it. (The history of science abounds in such cases).
5. Inferences based on the outcome of the preceding four steps.

More briefly still, four words mark the process: *Problem, hypothesis, evidence, inference.* All else is detail.

The part played by accepted theory—the outcome of a tested hypothesis—has been ably set forth by Professor Davis. If the reader is interested in geology he will do well to study with care the entire monograph in which Davis takes occasion to discuss the nature of theory.[1] The literature of geology is rich in material to which reference might be made for illustrations of the geologist's major task: that of transition from phenomena through explanation to evidence and inference; but the monograph just mentioned has in a marked degree a double value: it is a model of geological research and an exposition of scientific method.

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[1] William M. Davis, *The Triassic Formation of Connecticut.* (Eighteenth Annual Report of the U. S. Geological Survey, 1896-97.)

Happily for us the master-students sometimes take us into their confidence and describe their ways of accepting the challenge of the unknown. Thus Darwin in his Autobiography records, quite simply and frankly, "I think that I am superior to the common run of men in noticing things which easily escape attention, and in observing them carefully. . . . From my early youth I have had the strongest desire to understand or explain whatever I observed—that is, to group all facts under some general laws. . . . I have steadily endeavoured to keep my mind free so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it."[1] In the last paragraph of this autobiography its author declares that the most important elements in his success have been—"the love of science—unbounded patience in long reflecting over any subject—industry in collecting and observing facts—and a fair share of invention as well as of common sense."

Scientific temper is so intimately connected with scientific method that it may, indeed, be said to be a part of it. Those fallacies which take their source in temperament—a natural disposition to be inaccurate, to call an observation good enough when it is indifferently good, to exaggerate, to "jump at conclusions," to show partiality among evidences—all are hostile, if not fatal, to success in any investigation worthy of the term scientific. Consequently, the

[1] F. Darwin, *The Life and Letters of Charles Darwin,* Vol. I, p. 85.

austere training which one must give himself yields habits with an ethical tone.

Further, every judgment reached and marked knowledge—so long as it falls short of being a law—means progress rather than finality, because its connections and consequences summon the student to additional investigation. That mental elasticity so essential to scientific progress is passing into a fatal rigidity when one says: "There, I shall not have to think about that, any more; label it and put it away." Russell writes: "In science, where alone something approximating to general knowledge is to be found, men's attitude is tentative and full of doubt."[1] And Galton affirms: "We must be content to suspend our belief and maintain the freedom of our mental attitude, whenever there is strong reason for doubt. When there is stormy weather and no secure harbor the sailors put out to sea; it is not anchorage they then want, but sea-room."[2] In a similar vein, Russell, already quoted, says: "What is wanted is not the will-to-believe but the wish to find out, which is its exact opposite."

To the other qualifications for scientific work must be added with especial emphasis freedom from the bias of desire or prejudice. A recent summary[3] of knowledge in certain associated fields of science, with inference therefrom, admirably illustrates an entire freedom from those damaging twists, due to

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[1] Bertrand Russell, *Free Thought and Official Propaganda*, p. 15.
[2] Francis Galton, *Inquiries into Human Faculty*, p. 297.
[3] Harlow Shapley, *The Universe and Life*, Harper's Mag., May, 1923.

preconceived notions or insistent desires, which vitiate extra-scientific writing—much if not all of it. Quite apart from the interest in the subject discussed, Dr. Shapley's article is well worth studying as a model of the way in which a man of science conducts his thinking when searching for inferences warranted by a vast range of facts of which he has a commanding knowledge.

Even a hypothesis must be postponed until ample material warrants one. Darwin opens the Introduction to his greatest work by mentioning the phenomena which first drew his attention to the problem of the origin of species. He goes on to say: "It occurred to me, in 1837, that something might perhaps be made out on this question by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it. After five years' work I allowed myself to speculate on the subject, and drew up some short notes; these I enlarged in 1844 into a sketch of the conclusions which then seemed to me probable; from that period to the present day I have steadily pursued the same object." (*The Origin of Species* was first published in 1859.)

Another impressive example of method is found in the work of the distinguished astronomer, Kapteyn, who devoted his life to the problem: What is the structure of the visible part of the universe? Kapteyn started with the supposition that the stars in their motions show no preference for any special directions; that as many move one way as another, and that the average velocity in every direction is

the same. This wears the air of a hypothesis, but it is in reality the denial of one; preconceived theories are refused consideration. Incidentally it is the opposite of Kepler's method. It turned out, however, that this negative supposition is not fulfilled in Nature. "But the failure was really a triumph; for the proof that the motions of the stars are not at random led Kapteyn to the exceedingly important discovery of star streams."[1]

But Kapteyn's investigations would have been quite impossible without the mass of observations—the work of other astronomers—furnished by the great observatories of the world. Contemporary coöperation, as has been earlier pointed out, is indeed one of the marked features of modern scientific method and progress. What might be called chronological coöperation is hardly less important. An example has already been given in the continuity of results achieved by Tycho Brahe, Kepler, and Newton.

Turning to the history of biology in the nineteenth century, the discovery of protoplasm may be selected from a group of dominant biological advances to show the emergence in due time of knowledge exceeding what any solitary investigator could be expected to bring to light. As early as 1755 this "living substance," now known as protoplasm, had been incidentally observed; but in 1835 Dujardin, a French naturalist, published observations made in connection with simple animals such as various

[1] P. J. Van Rhijn, *Jacobus C. Kapteyn, In Memoriam.* Pop. Astron., Dec., 1922.

protozoa and worms. Through experiment he distinguished between this substance and gum, gelatine, white of egg, etc., which it superficially resembled. Finally, he described it as a "living jelly, endowed with all the properties of life," and gave it the name *sarcode* (flesh-like). But Dujardin did not recognize the extensive and distinctive rôle which his sarcode plays in nature. The conclusion that it was limited to lower animals satisfied students for some years. However, in 1840 the Bohemian anatomist, Purkinjé, described this peculiar substance under the name *protoplasm* (first formed) as existing in mammalian embryos. Six years later, von Mohl, a German botanist, announced its presence in plants, calling it protoplasma. Finally, Schultze, after a long series of observations and experiments, stated in 1861 that living substance, whether it be called sarcode or protoplasm, is essentially alike in plants and animals. Professor Locy concludes his historical sketch, of which the above is a summary, with the far-reaching statement: "If the naturalist is ever to bring vital activities under close analysis, he must do so by becoming acquainted with the properties and the behavior of protoplasm. Even in its simplest form it exhibits the germ of all properties that appear better developed in higher organisms."[1]

Looking at this fragment of the history of science from the point of view of induction, chapter V, it will be noted that four investigators: a naturalist, an anatomist, a botanist, and a zoölogist, made the

[1] William A. Locy, *The Main Currents of Zoölogy*, p. 15.

decisive contributions to the establishment of the universal affirmative: All organisms are characterized by the presence of protoplasm, and in this physical substratum all vital activities exhibit their manifestations.

At this point the average man, whose daily efforts must be directed toward his job of securing food, clothing, and shelter, is liable to say: Yes, no doubt those rules and qualifications are good and necessary for laboratory folks; but they have nothing to do with me; I don't pretend to be a man of science." In reply it cannot be too strongly stated that "common sense," good judgment as exhibited in the ordinary affairs of life, is merely the homely practical side of the method that goes by the term, scientific, the form of mind behavior which personally concerns every responsible human being. It is quite generally supposed that if one have native good sense, training is superfluous; and if he have it not, training is useless. But probably no one ever possessed such a measure of natural good judgment that it could not be bettered by an understanding of its own characteristics and workings; nor is any one so destitute of common sense that a study of certain rules and an effort to put them into practice could not greatly improve his mental conduct and hence his behavior as perceived by his fellows. The matter with the man who went over the hills to salt the cattle was that he had no appreciation either of his duties or his privileges as a creature with a brain potentially better than that of his dog. He muddled along from year to year with scarcely any gains in

information and—what was more serious—without improvement in intelligence.

Since knowledge, organized as science, comes so largely through testimony it may properly be asked regarding men of science, as in the case of historians, how is a person who is not an expert to know whose testimony may be depended on. In answer it is to be said that he cannot positively know without some guiding acquaintance with at least an introduction to the science in question. But he will discover—if he keeps on—that men of science, in a greater degree and with stronger motives than those which obtain with other persons, are anxious to report aright what they have observed, or inferred, or received from others. Jealous for their subjects they hold a fraternal but unsparing watch on one another. The checks are many and a charlatan or an incompetent person is sure to get found out. Careless measurements in physics, indifferent observations of rock-relationships in geology, bungled dissections in zoölogy, all react to the undoing of him who is unfitted or unfaithful—or both. But pride in the handling of his job, a proper ambition to acquire good repute among his fellow-workers, a purpose to make even a slight inroad into the unknown—these elements combine to form a powerful force in securing the utmost of devotion and effort. And this positive influence for worthy achievement is, as a rule, very much greater than the negative one mentioned: the fear of later exposure of work so ill-done as to assume the form of untruthful testimony, found to be untruthful and thence repudiated.

To take a practical example—suggested by an earlier chapter—of the nature of testimony in science, how do we come to depend on Gray's *Manual of Botany*—perhaps not to the extent of "swearing by it," but certainly as a thoroughly reliable guide in systematic field study of plants? We know, or may easily learn, that many field botanists who are acquainted with plants at first-hand are using it; if this manual abounded in errors, or even if it had a sprinkling of them, the facts would be brought out forthwith in botanical journals; as a text-book it would speedily correct its errors or give way to a rival. But the author, and after him the revisers of this text, seem to have been resolved to produce a manual which should be as free as possible from any ground for legitimate criticism.

Even in that least exact of all sciences—sociology, including politics and economics—the writer desiring to be accepted as scientific knows that if he yields to the temptation to indulge in assertions which are prejudiced and unsustained by that final judge, the facts in the case, he will some day get found out and be accordingly discounted or discarded. A twofold suggestion results: any one attempting the rôle of sociologist needs a serious and prolonged apprenticeship in some acknowledged science; and needs also to carry with him into sociological work those habits which he gained in the laboratory or the field.

CHAPTER XV

Summary and Conclusion

In the ground now covered a theory of the origin and development of the brain has been outlined; emphasis has been placed on the continuity and gradualness of that development, resulting, as it has, in consciousness with capacity not only to store but to revive, organize, and utilize, perceptions. Using the term "mind" as a brief and convenient one to denote consciousness invested with intelligence, p. 37, its main achievements have been stated: the attainment of the concept, the realization of the nature of evidence and thence of inference, the grasp on various laws—especially that of cause—and thence on the nature of law in the field of science. The outcome of this degree of development has been shown to be not merely a possible proprietorship of knowledge itself but of the essential modes of mind behavior by which alone knowledge is to be acquired. The immaturity, the feebleness and awkwardness, of the mind have been disclosed through a discussion of the fallacies which so generally beset unguarded mental action, with the underlying fallacious tendencies which characterize the mind.

But immaturity implies subsequent growth, feebleness suggests possibilities of strength, development itself denies completion. The brain as the master organ of the body has thus far administered rather badly its lordship over the body. The appointments

of civilization—themselves expressions of applied science—may seem a benefit to the race; but the body, brain directed, does not yet conduct itself wisely in the environment which it has superposed on that primarily furnished by Nature. We do not know what to eat, how to dress, how to busy ourselves, or how to behave, to the advantage of the individual and all society. Nor shall we ever know except as the mistake-making mind improves. In what direction may advantageous development be looked for?

As noted in an early chapter, behavior depends not merely on immediate stimulus but on the aggregate of life's experiences. But some experiences are more to the front than others and hence influence behavior more effectively; those in the background count for little though they may be of the utmost importance. Thus a person keeps on committing fallacies because he rarely notices them; nor is he much impressed or disturbed when he does notice them; they belong to an insignificant and vague background. The first step, then, is clear recognition of the common fallacious tendencies of the mind; the next is incorporation in schemes of education of a systematic training directed toward the control and reduction of these tendencies. A reform so fundamental in educational methods will have to be carried on in the face of powerful elements in society which are conservative and also well equipped for resistance; these reactionary forces will, with all the means at their command, oppose any new strength and freedom of the common mind. Meanwhile,

"education" and "democracy" are terms widely used to disguise the denial of what they are naively supposed to denote.

One phase of the education which will address itself to filling up the pitfalls and placing lights along the trail which the mind must travel will be insistence not only on the nature of knowledge but also on a definite harmony among all knowledges—corresponding to the unity or self-consistency of the cerebrum. The poet tempts us to feel, the propagandist begs us to believe, the scientist invites us to know. But belief is unworthy and injurious except as it is directed and justified by knowledge. Intellectual honor and integrity forbid the attempt to establish that compartment-system of the mind which implies: "Over there is what I know on the ground of evidence which is objective, verifiable, and communicable; and here is what I like to feel and permit myself to believe—my comforting faith." Feelings —hopes, fears, joys, sorrows, desires—have their legitimate function; they have quite exceeded it when they are allowed to dictate either convictions or conduct.[1] To ignore now this distinction between knowledge and feeling is much as if we were to disregard the advantage of the upright position and add hands to feet for the purposes of locomotion, or to discard an articulate elaborated language in

[1] It has been suggested with much cogency that the home of the emotions may be in the polymorphous layer which presides over the lowest cortical functions such as those concerned in the getting of food, the sexual instincts, etc. The emotions certainly indicate a stronger affiliation for these polymorphous functions than for the products of the distinctly intellectual layers of the cerebral cortex.

favor of the undifferentiated throat sounds of our anthropoid ancestors. Just as such a reversion would cancel human progress thus far made, persistent confusion between the rôle of intelligence and that of emotion is a disastrous check to any real betterment of the intellectual and the ethical life of man.

Several corollaries—repetitions, in part, of what has already been said—form a conclusion.

1. The disconcerting fact faces us that training in a science—or in several of them—fails to guarantee a fixed and consistent habit of scientific behavior in all the situations of life. Both the method and the temper which mark laboratory activities are only too often left within when the man of science locks his laboratory door and joins the people of the street. Prejudice, party enthusiasm, intolerance, chauvinism, indifference to evidence—these grip the chemist and physicist, the biologist and geologist and astronomer, even as they do mere business men, literary folk, representatives of Church and of State, and the industrial workers. This is not a reproach to science itself, but to those followers of science who have failed to perceive that human society, not less than the physical environment of society, abounds in problems which can only be solved by those very methods which must be used by him who would successfully question Nature. Bertrand Russell writes: "The kernel of the scientific outlook is the refusal to regard our own desires, tastes, and interests as affording a key to the understanding of the world. Stated thus baldly, this may seem no more than a trite truism. But to remember it consistently in mat-

ters arousing our partisanship is by no means easy, especially when the available evidence is uncertain and inconclusive."[1]

Inconsistency in mental behavior cannot be regarded as inevitable until definite and carefully executed experiments in preparatory education show the futility of the new training suggested in this chapter. Gibbon, in his *Memoirs,* remarks: "Every man who rises above the common level has received two educations: the first from his teachers; the second, more personal and important, from himself." As the methods of the schools stand to-day, one must depend on himself for unremitting training in the method of science if it is to rule his life.

2. It is of the utmost consequence that every person presumed to be grown-up should pause from time to time and examine the bases of his beliefs. Is he holding this or that view or creed because it was taught him by parents or teachers early in his life, or because it is the usual and current belief in his community, or because his worldly interests are promoted by entertaining it, or, indeed, on any other ground than that of evidence? The defensibility or non-defensibility of a view so held is beside the mark; the point is that the person in question has not examined it for himself. The challenge of socially inherited beliefs—whether in religion, or politics, or other associated fields—wears the air of impiety; but one may have to choose between seeming impious and failing to contribute his share toward establish-

[1] Bertrand Russell, *Mysticism and Logic.*

ing for himself and his fellows a path of mental uprightness.

3. The Dawn Man's youngster, whose playmate was perhaps the captured cub of the wolf or the cave-bear, began life and continued it without precepts, rules, manners, catechisms, fairy stories, or family biography. His school-room was the wide out-of-doors where he must become nimble and alert or go hungry—perhaps worse. He observed the ways of his elders and imitated them, and that was all. To what a far extreme his descendants have been swept! To-day we are born, each one of us, into a composite social environment of habits that we must adopt, beliefs that we must accept, schools, churches, laws, customs, to which we must submit. From the hour when we begin to understand the talk of the tall folks around us we are loaded and overloaded with these social appointments, these accumulated ideas. Most of our formal educating consists in reporting to us what those gone before have thought and said and done. It is all meant for our good; but these directors hardly imagine the invasion of personality that they are engaging in. That invasion reaches its maximum when the young person is led to give assent to a creed which he cannot by any possibility understand and which his teachers cannot explain or verify. Economic doctrine, national egotism—known as patriotism—and racial bias, follow close on theological creeds in arresting growth and building up barriers to liberty. To maltreat a young human body so that it remained that of a child in stature and strength into the years of man-

hood would be properly regarded as criminal. To prevent the growth of intelligence is an even greater crime; for the mind is the man, and to remain ignorant is to remain a slave—or a child. Caesar says he knew that "all men are naturally bent on liberty, and hate the state of slavery." Desire for mind freedom may be as natural as that for body freedom. The general absence of such desire may find its explanation in malformations artificially induced in the consciousness of the young.

4. Intimately related to the notion that feelings afford knowledge is the companion one that philosophy begins where science leaves off—with some inscrutable process of its own for taking the output of homely experimental labor which has obeyed the laws of evidence and inference, and with these fruits of the laboratory and field proceeding to higher ultra-scientific "truths." This notion invites recognition of another and more ancient one which ignores any offerings of science; a notion holding that philosophy, assuming a metaphysical character, may operate with its own premises and conclusions, wholly independent not only of the content but even of the procedure of organized correlated knowledge. Such philosophy has served from early times to damage the human mind; on its theological side it has been, and is, next of kin of superstition itself, ably aiding in those interferences—when they were not persecutions—which for centuries prevented any open study of Nature. The true criticism of metaphysical philosophy, as Strauss said of dogma, is its history.

The thousand years of the Middle Ages, including those known as "dark," might all be described with only too much truth as years of midnight. The nineteenth and twentieth centuries are so close to the gloom that free scientific thought and speech—especially in the field of sociology—even to-day are not safe from ancient menace in modern dress. Nor will it be possible to say that humanity has wholly escaped into light until the method of science, re-enforced by a new ethics, is the universal and ruling element in education and thence in the lifelong behavior manifested by minds informed and free.

APPENDIX

I. The Syllogism

When two sense impresses, perceptions, ideas, or concepts, are recognized as being alike in having identical properties or qualities this recognition is recorded in a *proposition.* The names or symbols of the sources of the sense impresses, or of the perceptions, ideas, or concepts, are called the *terms* of the proposition; the word-symbol for identity is the simplest form of the verb of being: *is* (or *are*). For example, the name, grass, marks something in our external world which is capable of impressing several of our senses—especially that of sight. When we say, Grass is green, we use a short form for, Grass is a thing which is green, thus declaring the identity of grass and some green things. Again, in the proposition, Honesty is the best policy, we have compared honesty and best-policy behavior and we record them as identical.

The symbol of that to which the property or quality is declared to belong is the *subject* of the proposition; the other term, symbolizing this property or quality or characteristic, is the *predicate.* In the first example given, green—or, more fully, a thing which is green—is the predicate.

A corresponding proposition, negative in form, serves to deny identity of the subject and predicate. For example, in saying, No crystals are alive, we

deny connection between crystals and things which are alive.

Four forms of the simple judgment-proposition arise. Thus if we say, Dogs are quadrupeds, we assert agreement (identity) between the subject, dogs, and the predicate, quadrupeds; and when we do so we mean all dogs but not all quadrupeds. They cannot be all quadrupeds, for there are cats, horses, etc. We have here the predicate covering more cases than the subject. This fact is expressed by saying that the subject is *distributed* and the predicate is not; and this form of the proposition is known as the *universal affirmative.* ("Distribute" and "universal" are not especially suitable words, but they have the endorsement of usage.)

Again, let us take the statement, No dogs live in water. Comparing all dogs and all things that live in water we declare that there is no agreement (identity); the two classes are mutually exclusive. Both subject and predicate are distributed and the proposition is a *universal negative.*

Thirdly, let us say, Some dogs are hairless; that is, Some dogs are some things that are hairless. Here the predicate contains more than the subject, though neither subject nor predicate is distributed. The proposition is a *particular affirmative.*

Finally, suppose the proposition is, Some dogs are not good watch-dogs. Evidently the subject is not distributed; we say, some dogs. But the predicate, good watch-dogs, is distributed; some dogs are wholly outside the class—the entire class—good watch-dogs. This form is the *particular negative.*

Letting X represent subjects and Y represent predicates, these four forms may be symbolized thus:

All X is Y, denoted by A, universal affirmative;
no X is Y, denoted by E, universal negative;
some X is Y, denoted by I, particular affirmative;
some X is not Y, denoted by O, particular negative.

The reader should try to form others; he will soon reach the universal affirmative: Every categorical proposition belongs to one of these four forms.

We may now put two judgments together and discover that a third is necessarily contained in them. For example,

if we say, All pinks are fragrant;
and also say, this flower is a pink;
we must add, this flower is fragrant;

for whatever is true of all pinks must be true of any particular pink.

It will be noted that to get the third proposition the first two need to have a term in common—something to tie them together, as it were. Thus if the statements are,

all pinks are fragrant;
some roses are white;

no third proposition emerges, for the two given have nothing in common.

Further, besides that common term in the first example, there is one term, fragrant (things), of the first proposition not found in the second; and one term, flower, in the second which is not found in the first; and these two appear in the third proposition. This resultant (third) proposition is the *conclusion,*

the other two are *premises.* The premise which contains the subject of the conclusion is known as the *minor premise* and that subject is the *minor term;* the premise which contains the predicate of the conclusion is the *major premise* and that predicate is the *major term.* The connecting term, common to the two premises and not appearing in the conclusion, is called the *middle term.*

The order of the premises is immaterial; the conclusion naturally stands last, though in writing and in ordinary speech it is often placed first, while one of the premises may be unexpressed though distinctly implied. Thus if we say, This flower is fragrant, for it is a pink, we mean formally,

All pinks are fragrant;
this flower is a pink;
therefore it is fragrant;

or

This flower is a pink;
all pinks are fragrant;
therefore it is fragrant.

Notice that the minor premise occupies the second place in the first form and the first place in the second form.

Three propositions related as just described form what is known as a *syllogism.* Studying the syllogism further we find a large number of ways in which the four kinds of categorical propositions may be combined—so far as form goes—though most of them upon examination have to be discarded. The first syllogism used above is seen to have in order an A premise, an I premise and an I conclusion;

that is, it is an AII syllogism; while the second—interchanging the premises—is one in IAI. Making a systematic set of all possible arrangements we have the following Table:

AAA	AEA	AIA	AOA	EAA	EEA	EIA	EOA
AAE	AEE	AIE	AOE	EAE	EEE	EIE	EOE
AAI	AEI	AII	AOI	EAI	EEI	EII	EOI
AAO	AEO	AIO	AOO	EAO	EEO	EIO	EOO
IAA	IEA	IIA	IOA	OAA	OEA	OIA	OOA
IAE	IEE	IIE	IOE	OAE	OEE	OIE	OOE
IAI	IEI	III	IOI	OAI	OEI	OII	OOI
IAO	IEO	IIO	IOO	OAO	OEO	OIO	OOO

When the plan followed in making these sixty-four syllogisms is seen the Table may be written without effort or remembering. We have now to discover the basis for selecting from the Table the syllogisms which are valid. For this purpose let X represent the minor term, Y the middle term, and Z the major term.

Consider, for example, the premises,

All pinks are fragrant; (all X is Y)
some fragrant flowers are visited by bees; (some Y is Z)

The first premise, as already noted, means all pinks are some fragrant things (flowers); but the "some fragrant flowers" which are visited by bees are not known to be the same some fragrant flowers which are pinks. Therefore we cannot conclude that all pinks are visited by bees; we cannot even conclude that some pinks are. The difficulty is in the middle term; the part referred to in one premise may not

be the part referred to in the other, and hence this term does not serve to bind the two premises together; it is said to be *undistributed.* Cases like this afford

RULE I. *The middle term must be distributed in at least one premise.*

But why not in both? To answer this question take the premises,

All pinks are fragrant; (all X is Y)
all fragrant flowers are visited by bees; (all Y is Z)

The middle term is distributed in the second premise but not in the first. Pinks, being some fragrant flowers, must be included in "all fragrant flowers," and hence we must conclude that all pinks are visited by bees. The distribution of the middle term in that first premise is plainly unnecessary.

Secondly, suppose we say,

Some orchids are swamp plants; (some X is Y)
all swamp plants love water; (all Y is Z)
therefore all orchids love water. (all X is Z)

Here the middle term is distributed, but evidently we cannot draw the conclusion given, making a statement about all orchids; because, in the premise, only some orchids were mentioned. We may, however, say that some orchids love water, the correct syllogism being IAI.

The fallacy of distributing the minor term in the conclusion when it was not distributed in its premise is known as the *illicit process of the minor term.*

Again, suppose the premises are,

No savage languages contain abstract terms;
(no X is Y)

all languages containing abstract terms are difficult; (all X is Z)

shall we conclude

no savage languages are difficult? (no X is Z)

No, because in this conclusion—a universal negative—both terms are distributed; whereas the predicate, Z, is not distributed in the premise in which it occurs. Languages may lack abstract terms and yet be difficult for other reasons. The fallacy in this case is the *illicit process of the major term.*

To meet the two fallacies just noted we have

RULE 2. *No term may be distributed in the conclusion which has not been distributed in its premise.*

Thirdly, consider the premises,

All passenger pigeons have been exterminated; (all X is Y)

no exterminated birds have been domesticated; (no Y is Z)

We must evidently draw the conclusion, no X is Z, because all of X is declared to be a part of Y and none of Y is any Z at all. That is, in the illustration the premises mean that

no passenger pigeons have been domesticated; (no X is Z).

Since the whole includes the part, we could also say, Some passenger pigeons have not been domesticated; but a conclusion is naturally made a universal if the premises allow it. As another case let the premises be

Some kinds of grapes are not fit for raisins; (some X is not Y)

all kinds of grapes that grow in California

are fit for raisins; (all Z is Y)
we have to say in conclusion,
some kinds of grapes do not grow in California.
(some X is not Z)

Such examples furnish

RULE 3. *If one of the premises is negative the conclusion must be negative.*

Fourthly, suppose the premises,
No rotating bodies are spherical; (no X is Y)
no footballs are spherical; (No Z is Y)
It is not possible to draw a conclusion as to any relation between rotating bodies and footballs, for the premises deny all connection between X and Y and also between Z and Y.

Or suppose
No rotating bodies are spherical; (no X is Y)
some pumpkins are not spherical; (some Z is not Y)
Again no conclusion can be drawn. We may change the position of the middle term, writing the above pairs of premises

No X is Y	No X is Y
no Y is Z	some Y is not Z

but nothing is gained by doing so.
One other combination of negative terms, OO, remains. Given in symbols,

Some X is not Y	Some X is not Y
some Z is not Y	some Y is not Z

The reader will see that neither of these two forms affords any statement of relation between X and Z. All the combinations of negative premises are now exhausted and we sum up their consideration in

RULE 4. *From two negative premises no conclusion can be drawn.*

Attending now to the cases in which both premises are particular, the only possible ones are: OO, II, IO. The first, OO, has just been disposed of; II violates Rule 1, no term is distributed. IO may be written

Some X is Y	Some X is Y
some Y is not Z	some Z is not Y

In the first form the middle term is not distributed. In the second, by Rule 3, the conclusion, connecting X and Z, must be negative; but this would distribute X or Z (or both), whereas neither is distributed in its premise, thus violating Rule 2. Hence we have

RULE 5. *From two particular premises no conclusion can be drawn.*

Finally, if the reader will write all forms containing one universal and one particular premise—omitting those which violate any of the preceding rules—he will reach

RULE 6. *If one premise is particular the conclusion must be particular.*

The Table, p. 210, when examined in the light of these six rules, proves to contain only twelve valid syllogisms. But since the order of the premises is immaterial, five out of the twelve are duplicates of another five; that is, AEE = EAE, AII = IAI, etc. Consequently, the twelve reduce to seven; of these seven, six contain an A premise. The universal affirmative dominates all the others. The significance of this fact is referred to in chapter V.

Propositions are said to be *converted* when the

subject becomes the predicate and the predicate the subject, with due regard to distribution.

Thus, All X is Y enables us to say, Some Y is X, because the universal affirmative means, in general, All X is some Y.

Again, if no X is Y, no Y is X; this is due to the fact that both subject and predicate are here distributed.

As regards the particular affirmative, if some X is (some) Y, some Y is some X.

Lastly, a special device must be resorted to in order to convert the particular negative. If some X is not Y, we cannot say, Some Y is not X, for this deals with all of X, whereas only some X is given; but by using a hyphen the proposition may be written, Some X is not-Y, and the O proposition becomes one in I which is converted into, Some not-Y is X. In illustration two cases may appear. Thus if we say, Some roses are not red, this may mean:

(a) Some roses are not red (roses);
or (b) some roses are not red (flowers).

In case (a) the proposition might be written, symbolically, Some X is not aX, in which a is the adjective marking off a part of X, X itself being equal to aX + bX + cX + etc. Clearly we cannot say, Some aX is not X; that is, some red roses are not roses.

In case (b), (some roses are not red flowers), it seems correct to write conversely, Some red flowers are not roses. But here a bit of common knowledge —not covered by (b)—slips into one's thinking; and this knowledge is not legitimately used. For

we have only the face value of the given proposition to go upon; we cannot assume anything about red flowers—all of them or some of them. Indeed, so far as (b) informs us, the other "some roses" might coincide in extent with all red flowers; hence we certainly cannot say, Some red flowers are not roses.

This fourth form of conversion affords its chief value in showing the care that must be taken in syllogistic operations to limit a propositon to its exact content, unmodified by obvious facts from other sources.

As suggested by various preceding forms the position of the middle term is not fixed; it may be:

1. Subject of the major premise and predicate of the minor;
2. Subject of the minor premise and predicate of the major;
3. Subject of both premises;
4. Predicate of both premises.

The six rules governing the syllogism hold, of course, in all four of these cases.

Further, it is not always possible, in advance of a statement of the conclusion, to say which is the major premise and which the minor. Thus from

All Y is X	All Y is X
all Y is Z	some Y is Z

we may in each case affirm, Some X is Z, or some Z is X. With the conclusion, Some X is Z, the leading premise is the minor premise; with the other conclusion (some Z is X) the leading premise is the major one. But since the conclusion, Some Z is X, is merely the first form of the conclusion (some X

is Z) converted, this conversion of the conclusion has the additional back-action property of making the minor premise the major one and the major premise the minor one.

But using the two universals,

All Y is X
no Y is Z

we are limited to the conclusion, Some X is not Z. That is, we know in advance in this case, which must be the minor premise. It may be observed in passing that these AE premises yield only an O conclusion because the middle term is the subject in each premise.

The reader is warned not to attach undue importance to the major premise on the ground that it contains the word "major." As already seen, this premise is not necessarily the one that "leads off" in the syllogism; nor is it necessarily the universal that must be present. It has no characteristic except that of containing the predicate of the conclusion.

As regards the fallacies which consist in violations of the six rules above disclosed, Bain writes: "By far the most fertile source of purely syllogistic fallacies is the tendency of the mind to convert universal affirmatives without limitation. The usual form of the language, all X is Z, unless we are specially put on our guard, is apt to be interpreted as if X and Z were co-extensive; in other words, we are disposed to regard it as justifying the simple conversion, all Z is X. The errors of syllogism, under such names as Undistributed Middle and Illicit Proc-

ess, mostly grow out of this subtle error of conversion."[1] As an illustration, suppose we say, All Democrats believe in free trade. Unless one is cautious he easily turns it around and thinks, All who believe in free trade are Democrats.

Thus far the universal propositions dealt with have been strictly absolute, "all," "no." It is now necessary to consider certain tempering words whereby universals become *sub-universals*. Thus we may have "almost all," "probably," "as a rule," "the majority of," "so far as we know," X is Y. These propositions may serve in a syllogism if the conclusion is correspondingly modified. For example, if it be said, Most Republicans are protectionists; this man is a Republican; it can safely be concluded, the chances are that he is a protectionist, though with the major premise as given one cannot affirm unqualifiedly that he is.

Similar modifications of the particular are made by the use of "hardly any," "few," "to a limited extent," and the like.

Exercises

1. Write the valid forms of the syllogism to which the Table, p. 210, reduces and note the effect of assigning the middle term in turn to each one of its four possible positions.
2. Why does the predicate contain more than the subject in the proposition, Some dogs are hairless?
3. Most roses are fragrant;
   this flower seems to be a rose;

[1] Alexander Bain, *Logic*, p. 144.

(Conclusion?)

4. It must have been an acid, for it turned blue litmus-paper red.

(State in the form of a syllogism and examine its validity.)

5. We are liable to have a frost to-night, for it is clearing off.

(Syllogism?)

6. 60 per cent. of the voters were liberals;
50 per cent. of the voters were taxpayers;
(Write the correct conclusion).

7. Most men are uneducated;
most men are superstitious;
(Conclusion?)

8. "Nature has no purposes, for she has no will."

9. "He cannot be brave, for he opposes war."

(State 8 and 9 as complete syllogisms).

10. The sugar-cane flourishes (only) in tropical and sub-tropical regions; it flourishes in Louisiana.

(What is the force of the word, only?)

11. "Sleep has nothing to do with consciousness and memory, for it (sleep) occurs in plants."

—J. Loeb.

(Write the formal syllogism).

12. "If each spiral nebula is a stellar system, it follows that our own system is a spiral nebula."

(State in syllogism and examine the validity of the conclusion).

13. 'The people should rule over their political and industrial affairs, for these things concern them."

(Express in syllogistic form, supply the missing premise).

14. Lord Avebury says, "Savage languages are extremely poor in abstract terms." If we thence conclude that no savage languages are philosophical, what second premise has been used?

15. Does the assertion, "Taxation without representation is tyranny," imply a property qualification for voting?

All who pay taxes should vote;
Smith does not pay taxes;
therefore Smith should not vote.

(By reference to the quotation from Bain, p. 217, explain the fallacy in this conclusion).

16. Some right measures are radical;
all radical measures are disapproved;
(Conclusion?)

17. Patriotism is not instinctive, for it is acquired through instruction or folk-ways.

(Is the missing premise the major or minor one?)

18. Convert the propositions:

(a) Some limestones are not fossiliferous (rocks);

(b) Some limestones are not fossiliferous (limestones).

Account for the natural conclusion: Some fossiliferous rocks are not limestones.

The propositions thus far dealt with in this Appendix are categorical, that is, unconditional. We have now to consider a second class known as hypothetical. Hypothetical propositions, in turn, fall into two classes and give rise to the *hypothetical*

syllogism. Conditional propositions are marked by the word, if, or its equivalent.

The conditional syllogism contains one premise which is conditional in form while the other premise is categorical. Two fundamental cases arise:

(1) If A is B, C is D;	(2) If A is B, C is D;
A is B;	C is not D;
therefore C is D.	therefore A is not B.

"A is B" is known as the *antecedent,* and "C is D" as the *consequent.* The conditional premise in each case is, in reality, a disguised categorical proposition, being equivalent to:

All cases of A being B are cases of C being D; when we add:

this is a case of A being B, we must conclude that this is a case of C being D.

Evidently the syllogism is one in AII.

(Note. The new use of the capital A in hypothetical propositions must not be confused with the A of the Table, p. 210).

Also (2) may be stated:

All cases of A being B are cases of C being D;
this is not a case of C being D;
therefore this is not a case of A being B.

and the syllogism is one in AOO.

Now, if we deny the antecedent, saying:

This is not a case of A being B; and thence conclude:

this is not a case of C being D,

we have the major term distributed in the conclusion although it was not distributed in its premise. Rule 2, p. 212, is violated.

Again, if we affirm the consequent, declaring that C is D, or, more fully: this is a case of C being D, and thence conclude: this is a case of A being B, the middle term is undistributed and thus Rule 1, p. 211, is violated.

The preceding analysis furnishes the Rule governing the conditional syllogism:

Either the antecedent must be affirmed or the consequent denied. Affirming the antecedent, the consequent must be affirmed in the conclusion; denying the consequent, the antecedent must be denied in the conclusion.

In addition to the above cases, 1 and 2, we may have the following:

(3) If A is B, C is not D;
C is D;
therefore A is not B.

(4) If A is B, C is not D;
A is B;
therefore C is not D.

(5) If A is not B, C is D;
A is not B;
therefore C is D.

(6) If A is not B, C is D;
C is not D;
therefore A is B.

(7) If A is not B, C is not D;
A is not B;
therefore C is not D.

(8) If A is not B, C is not D;
C is D;
therefore A is B.

(9) If A is B, either C is D or E is F;
A is B;
therefore either C is D or E is F.

(10) If A is B, either C is D or E is F;
neither C is D nor E is F;
therefore A is not B.

It will be seen that this list does not exhaust the possible cases of the conditional syllogism; it is also important to note that the rule governing the two primary cases holds for the above and all similar ones.

The second class of hypothetical syllogisms, namely, the disjunctive, consists of a disjunctive premise (marked by the words, either, or) combined with a categorical one. The simplest case offers the disjunctive premise: Either A is B, or C is D; with four associated categorical premises:

1. A is B;	hence	C is not D;
2. A is not B;	"	C is D;
3. C is D;	"	A is not B;
4. C is not D;	"	A is B.

Again, with the premise:
Either A is B, or C is not D, we have,

1. A is B;	hence	C is D;
2. A is not B;	"	C is not D;
3. C is not D;	"	A is not B;
4. C is D;	"	A is B.

Other forms of the disjunctive premise are, for example:

Either A is B, or C is D, or E is F;
either A is B and C is D, or E is F;
either A is B and C is not D, or E is F and G is H.

These are sufficient to show that no definite limit exists for the forms of disjunctive hypothetical syllogisms; also the forms themselves suggest the appropriate categorical premises and the legitimate conclusions.

II. The Dilemma

By limiting the syllogism proper to such forms as contain at least one categorical premise a remaining combination is to be examined: that in which one premise is conditional and the other is disjunctive. This is known as the *dilemma*. For example:

If A is B, or C is D, E is F;
either A is B, or C is D;
therefore E is F.

Again,

If A is B, or C is D, either E is F, or G is B;
either A is B, or C is D;
therefore either E is F, or G is H.

It will be observed that in the first example the conclusion is categorical, whereas in the second it is disjunctive.

(Note. It is important to bear in mind the difference between the expressions,

either A is B, or C is D;
neither A is B nor C is D.

The second form is equivalent to: A is not B and C is not D; hence it cannot serve as the necessary disjunctive premise in a dilemma).

The dilemma is analogous to the hypothetical syllogism in allowing many variations in its premises; the two examples presented above sufficiently indi-

cate the proper method to be followed in reaching a conclusion. It remains to add that the disjunctive hypothetical syllogism is often mistaken for a dilemma and called such by writers who seem to be unaware that a dilemma is always characterized by a conditional premise and a disjunctive one.

Exercises

1. If the planet Venus shows phases like the moon, it must shine by reflected light.

(Complete the syllogism).

2. If the Free Soil party had been less pronounced in 1852, the Republican party would not have been formed in 1856; since the former party was very pronounced, the latter was launched.

(Is this a sound conclusion from the premises?)

3. With the premise, Either A is B, or C is D, or E is F, write all the categorical premises that may accompany it and state the corresponding conclusions.

4. "He will either be strong or he will be weak. If he is strong, then I say, if he is strong of heart he will boast of his relations with us; and if he is weak, he will be afraid of the results of having been intimate with us. In either case he is lost."

—A. Dumas, *The Black Tulip,* p. 22.

(Reduce this argument to symbolic form—using as many letters of the alphabet as seem to be needed. Show that it contains two dilemmas).

5. "Had you rather Caesar were living, and die all slaves, than that Caesar were dead, to live all freemen?" *Julius Caesar,* Act III, Scene ii.

(Write in a form to disclose the full meaning of Brutus' question. Is it a disjunctive syllogism, or a dilemma?)

6. If the Yenisei is shifted to its right bank, this is due either to geographic conditions or geodynamic forces.

(Complete the argument, stating it in symbolic form and classifying it. See p. 139).

7. "But the peculiar evil of silencing the expression of opinion is, that it is robbing the human race; posterity as well as the existing generation; those who dissent from the opinion, still more those who hold it. If the opinion is right, they are deprived of the opportunity of exchanging error for truth; if wrong, they lose, what is almost as great a benefit, the clearer perception and livelier impression of truth, produced by its collision with error."

—John Stuart Mill, *On Liberty*, p. 35.

(Show that a dilemma and a categorical syllogism are here involved).

III. The Universal Affirmative in Mathematics

Mathematics presents a remarkable body of exceptions to universal affirmatives in general, in that the predicate is more frequently distributed than not; All X is Y being All X is all Y. Such a proposition can evidently be converted into another universal. If all X is all Y, all Y is all X. Reference to Euclidean geometry shows that its theorems, whether categorical or conditional in form, usually imply a distributed predicate. For example:

If the diagonals of a plane quadrilateral bisect each other, the figure is a parallelogram.
Categorically stated, All cases of the diagonals of a quadrilateral bisecting each other are cases of a figure being a parallelogram. Some cases or all? All, because, if we start with the assumption that the figure is a parallelogram, we prove that the diagonals bisect each other. This means that the conditional proposition, If A is B, C is D, can here be written, If C is D, A is B.

As a second example:

If two straight lines are parallel, they are perpendicular to the same plane; conversely, if two straight lines are perpendicular to the same plane, they are parallel to each other.

When apparent exceptions arise it is often found that a more complete statement of the proposition shows it to be no exception as regards distribution of the predicate. For instance, If parallels are intercepted between parallels, the intercepts are equal. But the converse, If intercepts between parallels are equal, the intercepted lines are parallel, is not necessarily true. A little consideration of the appropriate figure will show, however, that the initial conditional proposition as stated above is a partial statement; when fully expressed its converse holds.

Algebra follows geometry in offering many reversible propositions and processes. For instance, given the general equation of the second degree in one unknown quantity, $x^2 + ax + b = 0$; we find, upon solving the equation, that the two values (roots) which satisfy the equation depend, as we

might have guessed beforehand, in a definite and invariable way upon the quantities, A and B, their sum equalling —A and their product equalling +B. Conversely, with any two assumed roots, as r′ and r″, we may form the equation by writing,

$$(x - r')\ (x - r'') = 0; \text{ that is,}$$
$$x^2 - (r' + r'')x + r'r'' = 0.$$

The reader will find it worth while to study both geometry and algebra from the point of view suggested above: the distribution of the predicate, and the exchange of condition for conclusion and conclusion for condition; that is, the reversibility of antecedent and consequent. The significance of this fundamental difference between the universal affirmatives of mathematics and those of science has been pointed out in chapter VIII. It may be repeated here that the mathematical relationships of quantity or magnitude are not causal, while the opposite is true of the relationships of matter as disclosed by science.

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